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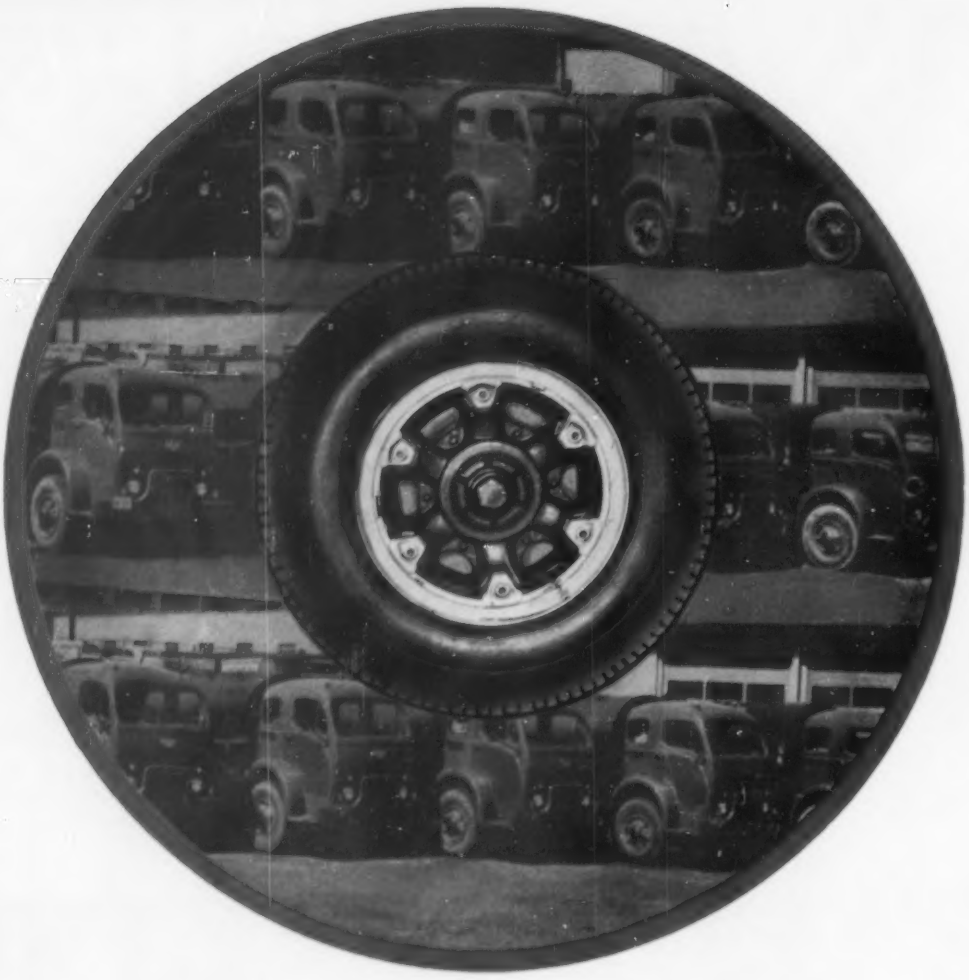

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President's page

by H. L. HEMMINGWAY, President, N L G I

Spreading the Word on Lubricating Greases

Although our industry depends on the lubrication of automotive equipment for a high percentage of our sales, and the automotive industry depends on us for suitable products, it is not often that our two industries meet to discuss mutual problems in public forum.

Such an opportunity has been presented, however, by the Society of Automotive Engineers at its Annual Summer Meeting. On Wednesday afternoon, June 15, there will be a Symposium on "Automotive Greases and Chassis Lubrication." In deference to N.L.G.I. your President was invited to be Chairman of the session and has accepted. Mr. J. W. Lane of Socony-Vacuum, a Director of N.L.G.I. and its representative to S.A.E., will be Secretary of the session. Participants will include many N.L.G.I. Member Companies, such as Lincoln Engineering Co., Esso Research and Engineering Co., California Research Corporation, Socony-Vacuum Oil Co., Standard Oil Co. (Indiana), The Pure Oil Company, and the Shell Oil Company. Our Technical Committee will be represented by its Chairman, T. G. Roehner, and by Mr. P. V. Toffoli, the new Chairman of the Subcommittee on Recommended Practices for Lubricating Automotive Front Wheel Bearings, who will discuss his sub-committee's activities.

The automobile industry will be represented by leading technicians who will present information on recent developments and trends in the field of automotive grease lubrication.

This should be a valuable discussion of mutual problems between our two industries. It may well re-direct and re-define lubricating grease product development. It cannot help but once again focus attention on the importance of lubricating greases in preserving the safety, performance, and long life which are built into modern automotive vehicles. Of such stuff is progress made.

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ABOUT THE COVER

The tangle of wispish design isn't visible to the naked eye, but does play a dominant role in this industry. Looking at it casually it might be almost anything from jungle growth to smoke designs.

Actually this is an electron micrograph of lubricating grease soap structure seen in Figure 2 of Dr. Hotten's paper on page 15. In the lower left corner is a drawing of an electron microscope. It's reported that it can magnify up to 1,000 times.

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Symposium . . .

STUDIES of GREASE STRUCTURE —A Basis for New Developments

Chairman W. M. Murray (left) opens session by introducing L. Brunstrum to NLGI Annual Meeting

***Introduction by* L. C. BRUNSTRUM, Standard Oil Company (Indiana)**

Lubrication with grease instead of oil provides certain advantages at the expense of additional technical problems. The semi-solid nature of grease insures retention in bearings but causes problems on dispensing. Slow leakage of oil from a grease provides long service but its control is the source of numerous leakage tests. Mechanical stability of grease may insure uniform service but its measurment and control was recently the subject of an ASTM symposium.

These and other advantages and problems are usually measured by emperical tests but result from the two-phase structure of grease. In a broad sense such a structure accounts for the unique flow, provides the network and the forces to hold the oil, and is responsible for mechanical stability. Therefore, inevitably grease specialists sought relief from the limitations of their emperical tests for viscosity, leakage stability, etc., in more fundamental studies of structure.

Significant progress has been made during the past decade. The symposium at the 1954 annual meeting of the National Lubricating Grease Institute was therefore a good time to summarize and discuss what is known about grease structure. Drs. Puddington and Hotten reviewed such work as electron microscopy, X-rays, dark field microscopy, birefringence, and rheology. They included their own ideas on what structure is required in a good grease. Drs. Leet and Vold described one recent industrial and one academic structure investigation, the latter being in addition to work on the NLGI Fellowship.

These papers were followed by a discussion among representatives of member companies led by Dr. Bondi. The following people from the United States, Canada, and Japan participated:

Earl Amott, Union Oil Company of California
Valeria Artel, University of Southern California
C. R. Bane, Richfield Oil Corporation
R. S. Barnett, The Texas Company
A. Bondi, Shell Development Company
C. J. Boner, Battenfeld Grease and Oil Corporation
R. O. Braendle, E. I. du Pont de Nemours and Company
L. C. Brunstrum, Standard Oil Company (Indiana)
D. B. Cox, Socony-Vacuum Laboratories
W. K. Dean, Mallinckrodt Chemical Works
George Entwistle, Sinclair Refining Company
W. J. Ewbank, Cato Oil and Grease Company
R. Fariss, Baroid Sales Division
H. M. Fraser, International Lubricants Corporation
B. W. Hotten, California Research Corporation
Hachiro Kageyama, Kyodo Yushi Co., Ltd. (Tokyo)
R. H. Leet, Standard Oil Company (Indiana)
J. J. Kolfenbach, Esso Laboratories
P. R. McCarthy, Gulf Research and Development Co.
A. L. McClellan, California Research Corporation
J. M. Musselman, Standard Oil Company (Ohio)
I. E. Puddington, National Research Council (Canada)
T. G. Roehner, Socony-Vacuum Laboratories
Robert Steinbruch, Minerals and Chemicals Corp. of America
Marjorie J. Vold, University of Southern California
R. D. Vold, University of Southern California
F. E. Woodward, Rock Island Arsenal
O. L. Yarham, Cities Service Oil Company

Left to right are Symposium members who delivered the papers on the following pages. They are: Brunstrum (panel chairman), Leet, Puddington, Vold, Bondi (summarized Symposium), Hotten. Others were part of panel listed on right.

The Structure of LUBRICATING GREASE

By

I. E. PUDDINGTON

Applied Chemistry Division
National Research Council of Canada

As late as 1931 lubricating grease was described as an oil-water emulsion stabilized by soap.[7] The present inadequacy of this definition, in view of the fact that some modern greases contain no oil, others contain no soap and very few contain more than traces of water, is perhaps indicative of the progress that has been made during the past twenty years in the development of these very important lubricants. It also raises the question as to what is required of a grease and how it must be constituted to meet the requirements.

Clearly, greases are functional products; their utility depends on their physical properties and the range of conditions over which these properties remain sufficiently constant to provide adequate lubrication. In common with all lubricants, a grease should possess a low viscosity when the bearings in which it is functioning are in motion. In addition, it should have the ability to solidify when the relative motion of the moving parts ceases. Further, this reversible solid-liquid transformation should be virtually instantaneous and be unaffected for long periods of operation under service conditions.

The ability to undergo reversible changes in apparent viscosity as the rate of shear is altered is found in suspensions where the particles of the solid phase tend to adhere on collision and form aggregates. When the system is at rest, the solid phase flocculates in such a way that the liquid is completely contained in the interstitial volume. An applied shearing force may disintegrate the flocs to a degree that depends on the rate of shear, and reduce the viscosity. The reverse process occurs when the shearing force is removed. Since in its normal state the system is coagulated, increased solid liquid interaction or increased stability will be reflected as a lowering of the yield value.

Models of such systems where an explanation of the interparticle adhesive forces is available can be obtained if a finely divided solid with an hydrophilic surface such as carbohydrate or silicous material is suspended in a water immiscible solvent and a small percentage of water added.[2, 8, 15, 20] The water forms a thin layer about the solid particles and when two or more particles collide, the water forms a neck between the particles and a force proportional to the surface tension at the water-oil interface is required to effect a separation. This system behaves like an unstabilized water in oil emulsion and coagulation is rapid. Similar demonstrations are apparently provided when suspensions of carboxyl iron in glycerol or magnetic oxide in linseed oil are exposed to a magnetic field.[12]

Over small shearing stresses the above models would be expected to behave as elastic solids, followed by flow if a critical shearing stress is exceeded. Virtually no recovery hysteresis would be expected unless the liquid phase were highly viscous, nor would a high temperature coefficient of yield value be anticipated.[1] Repeated cycles of shear and rest should have virtually no effect on subsequent measurements.

With soap base greases the methods of preparation usually leave the soap in the form of fibers with high axial ratios. This gives the possibility for mechanical entanglements in the flocs as well as the more specific adhesion possessed by the model particles. Since the soap fibrils tend to swell in organic liquids[16] a sintered or gel type of interparticle adhesion is also possible.

The agglomerated fibrous structure of the soap base lubricants has been indicated by a number of indirect observations. Dielectric, conductivity and rheological measurements[4, 5, 9, 13, 18, 27, 28, 35] have demonstrated both reversible and irreversible structural breakdown, and alignment of the fiber shaped soap particles during shear. Indications of high axial ratios of the particles by similar measurements[17, 29] have been confirmed many times since the advent of the electron microscope. The persistence of this solid phase structure has been clearly shown by the preparation of soap aerogels from greases and the reconstitution of the greases from the aerogels without

drastic alteration of properties of the original system. It is also possible to change the liquid phase of greases by a solvent exchange process.[6,8,26] These latter experiments have suggested a specific type of interparticle adhesion that is altered by changes in free surface energy at the soap-oil interface due to adsorption of impurities from a less highly refined liquid phase or by the use of an entirely different type of liquid phase.

A series of papers[31,32,33,34] has indicated the limited elastic properties of soap greases and the irreversible or very slowly reversible processes that follow repeated experiments that exceed the elastic limit. The expected faster recovery with low viscosity oil is also noted.

The importance of large axial ratios of the solid phase particles in producing greases with a suitable consistency for a given volume concentration of solids has often been stressed[4,5,12,17,18,22] and reference has been made to the abnormally large Einstein constants found for soap greases from flow property measurements. The obvious limit in this connection is reached if the particles change their axial ratio within a short time under service conditions. In this event the rheological properties of the grease after a brief period of use may bear little similarity to the carefully specified product that was applied originally to the bearing. This may be a useful change in many instances but its quantitative prediction would be difficult. The desirability of solid phase particles with a high axial ratio may also be questioned due to their contribution to the high shear viscosity of the product. If a viscosity with the least excess over that of the liquid phase is required at high rates of shear, then, obviously, the individual particles should be more nearly regular in shape.

The effect of individual particle volume on grease consistency does not appear to have been stressed previously although it can be demonstrated that desired yields can be produced with about 50% of the usual amount of soap if precautions are taken to produce small particle size.[10]

Changes in the rheological properties of soap base greases as the temperature is increased probably constitute one of their more important shortcomings. As the temperature is raised the yield value of the grease falls sharply, passes through a minimum, increases to a maximum and again falls.[23,24] Practically, the useful upper limit is the temperature at which the minimum in yield value occurs. This temperature appears to be related to the electro positivity of the metal ion contained by the soap molecule and the increase in yield value after the minimum is probably due to the appearance of a new soap phase.

In the case of sodium soap greases, and this may be typical of other greases to a lesser extent, the soap particles appear to be coagulated with a temperature sensitive force that is independent of fiber length and seems to be due to a sintering adhesion.[25] The high temperature coefficient of yield value that indicates this phenomenon is doubtless due to an increased solid-liquid interaction as the temperature is increased. Once broken down the high yield value is recovered only slowly at room temperature although recovery is virtually instantaneous if the grease is heated to 110° C and then cooled prior to measuring the yield value. This sort of interparticle adhesion probably accounts in a large measure for differences in worked and unworked penetration values. A freshly worked grease should show a low temperature coefficient of yield value as would be expected from the behavior of other thixotropic systems. This would alter on passing through temperature cycles, however.

The desirability of reducing the temperature sensitivity caused by soap-oil interaction and phase transitions in the soap[36] in conventional greases has probably led to the substitution of the soaps with more inert solids. Of the solids used, phthalocyanines, carbon, silica, asbestos floats and treated bentonites[19] are probably the more common. An interesting feature demonstrated by some inorganic fillers is the low volume concentration required to produce a very good grease. Finely divided silica, for example, in volume concentrations of 2-4% will produce greases with a penetration of 200-300.[21] Since the silica frequently does not have a high axial ratio but is of colloidal dimensions the importance of fineness of subdivision when compared to high axial ratios is obvious. This is also consistent with the requirement that the high shear viscosity of greases should be as close to that of the liquid phase as possible.

Desirable features of the non-soap greases are the thermal stability and the inert properties of the solid phase. These are reflected in a lower temperature coefficient of yield value than is encountered with soaps and the virtual absence of a melting point. It is of considerable interest to note, however, that if silica is coated with a hydrophobic monolayer the temperature coefficient of yield value is increased. This seems to indicate an increased solvent solid interaction at higher temperatures and an increased overall stability.

Although finely divided carbon has been used to some extent as the solid phase in greases, its oleophilic surface tends to produce a stable dispersion. Excessively large volume concentrations are therefore required to give reasonable yield values and undesirably large high shear viscosities result. The temperature coefficient of yield value also leaves much to be desired. The usual electrokinetic properties found in colloidal dispersions have been shown to exist in some systems in which the liquid phase is hydrocarbon[11] and the existence of charged particles due to the relative motion of the two materials of different dielectric constant has been suggested.[14,27] These effects may be significant in the behavior of carbon dispersions where a relatively small amount of permanent structure is found. An interesting effect has also been observed recently with silica that has been precipitated at different pH values. When this silica is converted into a grease either through the aerogel or solvent exchange process a marked maximum in the yield of grease is observed with the silica that has been precipitated at about pH 5,[28] a value recorded as the isoelectric point of silica.[3] The marked decrease in the yield value of the grease on either side of this maximum is indicative of the less coagulated, more stable system. A marked decrease in the free surface energy of silica under these conditions[37] and a decreased interaction of the solid particles due to the positivity or negativity of the surfaces on either side of the isoelectric point would be expected regardless of the liquid phase.

In summing up it would appear that a desirable type of grease structure is produced when:

1. A strong interaction that is only slightly affected by temperature changes exists between thermally stable solid phase particles;

2. The solid phase particles are sufficiently small individually that a low total volume is required to produce a grease;

3. The solid phase particles suffer no serious change dimensionally by mechanically working the grease.

REFERENCES

1. Arnold, J. E., and Goodeve, C. F., *J. Phys. Chem., 44*, 652, 1940.
2. Batchelor, H. W., *J. Phys. Chem. 42*, 575, 1938.
3. Bloomquist, C. R., and Shutt, R. S., *Ind. Eng. Chem. 32*, 827, 1940.
4. Bondi, A., Cravath, A.M., Moore, R. J., and Peterson, W. H., *Inst. Spokesman, 13*, 12, 1950.
5. Boner, C. J., *J. Phys. & Colloid Chem. 52*, 1383, 1948.
6. Browning, G. V., *Inst. Spokesman, 14*, 10, 1950.
7. Dunstan, A. E., in *Colloid Chemistry*, Vol. III, p. 498, J. Alexander, Editor, *The Chemical Catalogue Co.*, 1931.
8. Eggleton, A. E. J., and Puddington, I. E., *Can. J. Chem. 32*, 86, 1954.
9. Forster, M. J., and Mead, D. J., *J. Applied Phys. 22*, 705, 1951.
10. Gallay, W., and Puddington, I. E., Unpublished.
11. Garner, F. H., Nutt, C. W., and Mohtadi, M. F., *J. Inst. Petroleum, 38*, 986, 1952.
12. Harvey, E. N., *J. Colloid Sci. 8*, 543, 1953.
13. Hatten, B. W., and Birdsall, D. H., *J. Colloid Sci.* 7, 284, 1952.
14. Howe, P. G., and Puddington, I. E., to be published.
15. Kruyt, H. R., and van Selms, F. G., *Rec. Trav. Chim. 62*, 407, 1943.
16. Mardles, E. W. J., and Clarke, E. B., *Trans. Faraday Soc. 42B*, 295, 1946.
17. Mardles, E. W. J., and Puddington, I. E., *Faraday Soc. Discussions, 1951*, No. 11, p. 43.
18. Matthews, J. B., *J. Inst. Petroleum 39*, 265, 1953.
19. Matthews, R. R., *Petroleum Processing 5*, 1082, 1950.
20. McFarlane, J. S., and Tabor, D., *Proc. Roy. Soc. A202*, 224, 1950.
21. Milberger, E. C., and Swatik, L. J., *Inst. Spokesman 16*, 18, 1953.
22. Moore, R. J., and Cravath, A. M., *Ind. Eng. Chem. 43*, 2892, 1951.
23. Moses, G. B., and Puddington, I. E., *Can. J. Research, B27*, 616, 1949.
24. Moses, G. B., and Puddington, I. E.,*Can. J. Chem. 29, 996*, 1951.
25. Moses, G. B., Sirianni, A. F., and Puddington, I. E., *Can. J. Tech., 31*, 121, 1953.
26. Peterson, W. H., and Bondi, A., *J. Phys. Chem.* 57, 30, 1953.
27. Peterson, W. H., and Bondi, A., *J. Phys. Chem.* 57, 72, 1953.
28. Singleterry, C. R., and Stone, E. E., *J. Colloid Sci. 6*, 171, 1951.
29. Sirianni, A. F., Moses, G. B., and Puddington, I. E., *Can. J. Chem. 29*, 166, 1951.
30. Sirianni, A. F., and Puddington, I. E., to be published.
31. Vingradov, G. V., and Gvozdev, M. M., *Doklady. Akad. S.S.S.R., 86*, 341, 1952.
32. Vingradov, G. V., and Klimov, K. I., *Ibid. 71*, 307, 1950.
33. Vingradov, G. V., and Klimov, K. I., *Ibid. 71*, 697, 1950.
34. Vingradov, G. V., and Pavlov, V. P., *Ibid. 58*, 1677, 1947.
35. Voet, A., *Am. Ink Maker, 31*, 34, 1953.
36. Vold, M. J., and Vold, R. D., *J. Inst. Petroleum, 38*, 155, 1952.
37. Weyl, W. A., in *Structure and Properties of Solid Surfaces*, page 163 *et seq.* R. Gomer and C. S. Smith, editors. The University of Chicago Press, 1953.

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OPTICAL STUDIES of Lubricating Grease Structure

By

B. W. HOTTEN

California Research Corporation
Richmond, California

Modern optical tools have revealed fine details of the structure of lubricating greases which could only be speculated upon before. With this new knowledge has come a better understanding of the functional behavior of lubricating greases in terms of simple, basic principles. As a result, the lubricant formulator is becoming a "chemical architect" who designs lubricant structures with minimum dependence on expensive trial and error testing.

This review of optical studies on lubricating grease structure consists of three parts. First, the tools used and the type of information obtainable from them are briefly described. Then some general principles of lubricating grease structure which are being uncovered with the aid of these tools are summarized, quantitatively where possible. Finally, the influence of one of the most powerful optical tools, the electron microscope, on progress in the search for better lubricant gelling agents is mentioned.

The Optical Tools

Light Microscope—The light microscope reveals the size and shape of larger soap fibers, such as sodium tallow fibers, which are more than one micron in each dimension. Whole greases may be examined, but contrast between soap fibers and oil is poor unless polarized light or dark field illumination[3] is used. Sharp images of individual fibers are seen, as shown in Figure 1, when the oil is washed away (with diethyl ether) from the lubricating grease on a microscope slide, and the washed fibers are shadowed in a vacuum with aluminum vaporized from an incandescent filament. Magnification up to 1000 times can be obtained.

Electron Microscope—The electron microscope shows the size and shape of even the finest gelling agent particles. Washed and metal-shadowed specimens provide a good picture of the individual building blocks which form the framework of the lubricating grease structure.[5] Even surface details of soap fibers are clearly visible, as shown in Figure 2, which is an electron micrograph of the same lubricating grease fibers seen in the light micrograph of Figure 1. Currently, several workers in this field are attempting to improve sample preparation techniques so that a better picture of the arrangement of the particles in the undisturbed lubricant structure may be seen. Among techniques being tried are microtome sectioning and freeze-drying[12] and aerogel preparation.[10] Aerogel specimens give especially clear-cut pictures of the soap framework which supports the lubricating grease structure. In their preparation the oil is replaced by a solvent and the solvent removed above its critical temperature so that the skeletal structure does not collapse.

X-Ray Diffraction—There are at least three methods by which X-rays may aid the study of lubricating grease structure.

One method makes use of low-angle scattering of X-rays to measure the average size of particles about 0.001-0.2 micron in diameter.

A second method makes use of changes in diffraction of X-rays at various sample orientations. These indicate the extent of parallel alignment of unsymmetrical soap fibers in lubricating greases.[13]

A third, and especially interesting and fundamental method makes use of X-rays for the determination of the patterns in which gelling agent molecules are arranged within the crystals. An example of this use is a study of sodium laurate, sodium palmitate, and sodium stearate crystals.[8] The soap molecules in such crystals were found to be arranged with the salt group heads meeting one another and the molecules tilted to an axis of the crystal, as shown in Figure 3. Many more molecular patterns of this type must be determined before any worth-while generalizations relating internal structure and functional properties of gelling agents can be made. Spiral and intertwined fibers, such as calcium tallow soaps and lithi-

um hydroxystearate, are particularly difficult to analyze in terms of internal structure, although progress is being made in the analysis of similarly shaped biological fibers such as proteins.

General Structural Principles

Optical studies lead to the conclusion that the properties of gelling agent particles which are most important to bulk properties of lubricating greases are the "Four Ss": Size, Shape, Stickiness, and Strength.

Size—In general, the finer the particle the more powerful its gelling action. This relationship has been shown quantitatively for a series of lithium soap greases[7] which were increasingly stiff in consistency as the surface area per unit volume, a convenient measure of fineness for irregularly shaped particles, increased. This effect may be explained in terms of a more efficient use of material in the latticelike structure when the particles are finely divided—material is wasted if the struts which form the lattice are bulkier than necessary to support the load.

An arithmetic estimate of this effect is shown in the inset in Figure 4. An idealized cubical cell of rodlike soap fibers 0.1 micron in radius (r) by 1 micron in length (l) would contain a volume of soap, $\frac{12}{4}\pi r^2 l$, or 0.094 cubic micron, where the $\frac{12}{4}$ factor is used because 12 soap rods per cell are each shared among 4 cells. The volume of the whole cell, l^3, equals 1 cubic micron. The percentage of space occupied by the soap is 100 times the soap volume divided by the cell volume, or about 9. If the soap fiber radius is doubled, the soap volume rises sharply to about 40%. The coarser soap fibers are not only less economical, but they may yield greases having poor flow properties.

Shape—The conclusion that shape is not critical to lubricating grease formation is reached from the fact that particles differing widely in shape from spheres of silica through rods of lithium stearate to long stringlike fibers of sodium tallow soaps—all have served successfully as gelling agents. However, an unsymmetrical shape is generally favorable. Thus, one series of greaselike pastes made from Nylon textile fibers was found to be increasingly stiff as the fiber length was increased.[1] The sym-

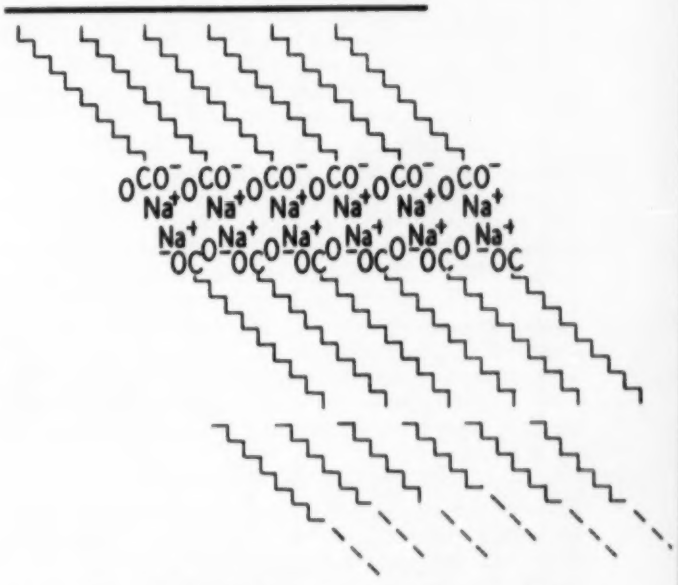

Figure 3. Arrangement of molecules in a sodium soap fiber.

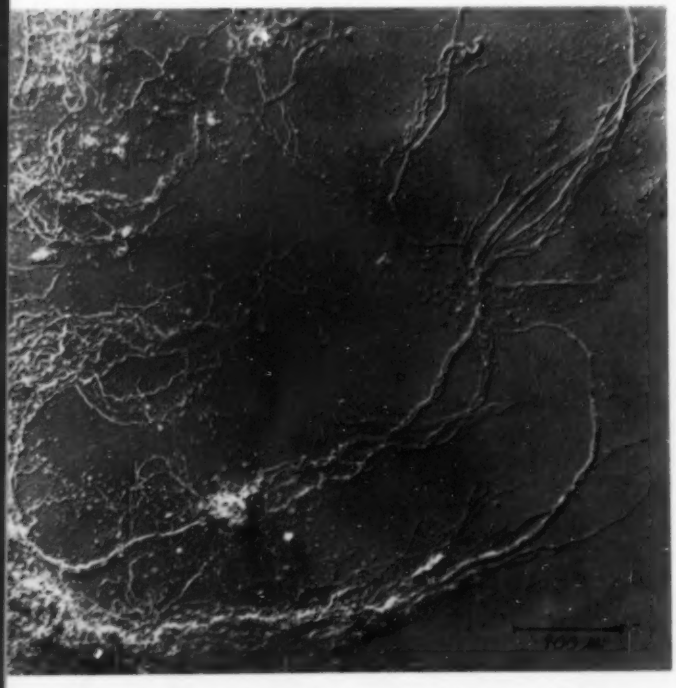

Figure 1. Light micrograph of sodium tallow soap fibers.

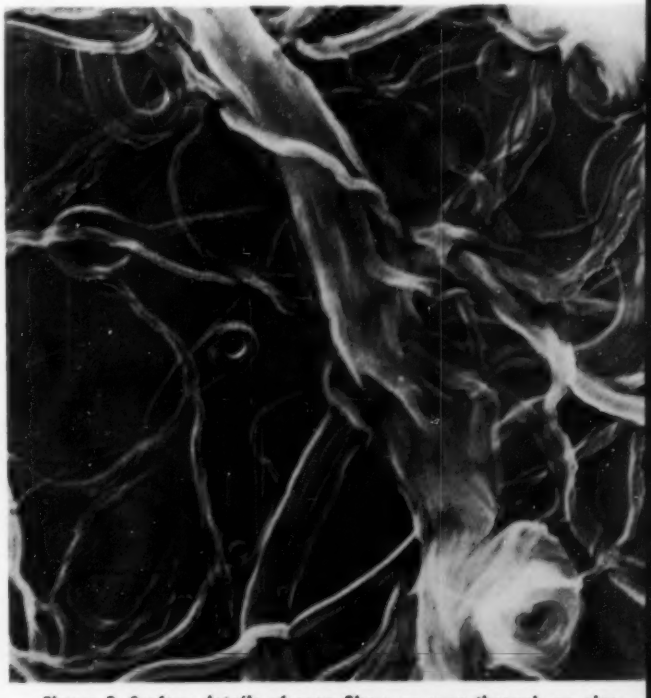

Figure 2. Surface details of soap fibers as seen through an electron micrograph of same fibers shown in Figure 1.

metrical particles which *are* effective thickeners, such as silica aerogel and acetylene black, are very fine and tend to agglomerate into loose, unsymmetrical clusters.

Particle shape is also important to grease texture. Well-known examples are the long, stringy, sodium tallow soap fibers which yield grossly fibrous greases and the rodlike sodium stearate fibers which yield smooth greases. This effect is shown quantitatively in Figure 5, based on a series of mixed sodium soap lubricating greases in which fiber length was varied by variation in proportion of stearate and oleate soaps. The gross stringiness, determined by pulling a 5-gram sample out vertically between two metal disks and measuring the length of string hanging from the upper disk, increases at first but then levels off as soap fiber length increases.

Stickiness—There is some evidence that gelling agent particles stick together to form the rigid framework of a lubricating grease structure, although few studies of this occurrence have been reported. One microscopic examination of silica dispersions in neutral and alkaline water showed a correlation between the degree to which particles stick together and the extent of formation of plastic, thixotropic systems.[5] Electron microscopic examination of grease aerogels also indicates a high number of apparently tight contacts among fibers.[10] Work stability (mild working) and age hardening are probably directly related to the strength and healing power of these contacts.

Strength—Resistance of individual lubricating grease fibers to breakage in moving bearings is probably an important determinant of service life. Recent studies show little breakage resulting from the mild shearing action of the ASTM grease worker, but extensive breakage resulting from the severe grinding action of antifriction bearings.[4] Thus, grease worker tests alone should not be depended upon for prediction of bearing life.

A diagram, Figure 6, summarizes some of the effects of the "Four Ss" on the fine structure of a typical lubricating grease—as it exists when undisturbed, and as it changes on pumping or during rotation in bearings. When the grease flows, the soap fibers separate and some of them line up parallel to one another. Under severe conditions, such as the grinding action of an antifriction bearing, many of the fibers also break into short fragments. As the grease comes to rest again the fibers rejoin, at least partially, to reform the network; but if extensive fiber breakage has occurred the grease may not recover its structure.

Expanding Chemistry of Thickener Formulation

Although the newer nonsaponaceous gelling agents might have been discovered by trial and error, the electron microscope probably has been an important stimulus and inspiration to their development. Electron micrographs demonstrate that there is no strict chemical barrier to the search for new gelling agents. Selection may be made from a wide variety of chemical types on the basis of melting point, thermal stability, water resistance, and crystal structure. Among the most interesting new gelling agents are attapulgite[9] (hollow needles), copper phthalocyanine,[2] and the arylureas[11] (both stubby rodlets). As a result of the many micrographs of successful gelling agents which are available, an electron micrograph alone of an untried mineral, pigment, or other finely divided powder can be a valuable basis for prediction of its gelling power in oil and even offer clues to some of the flow properties of the lubricating greases which may form.

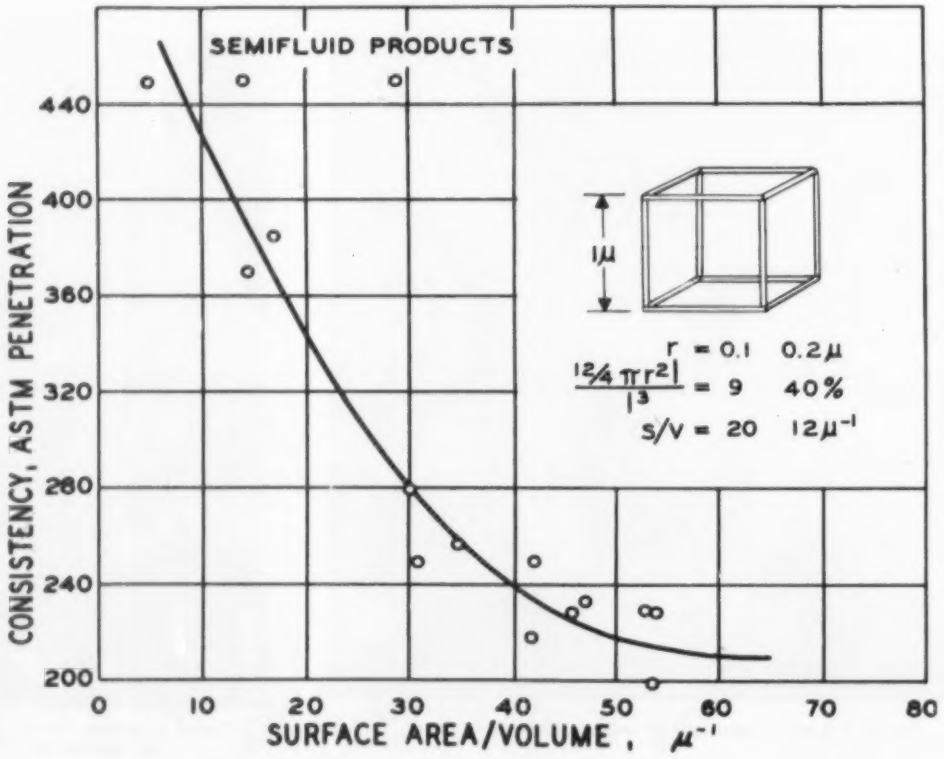

Figure 4. Effect of surface area-volume ratio of soap fibers on consistency of lithium soap lubricating greases.

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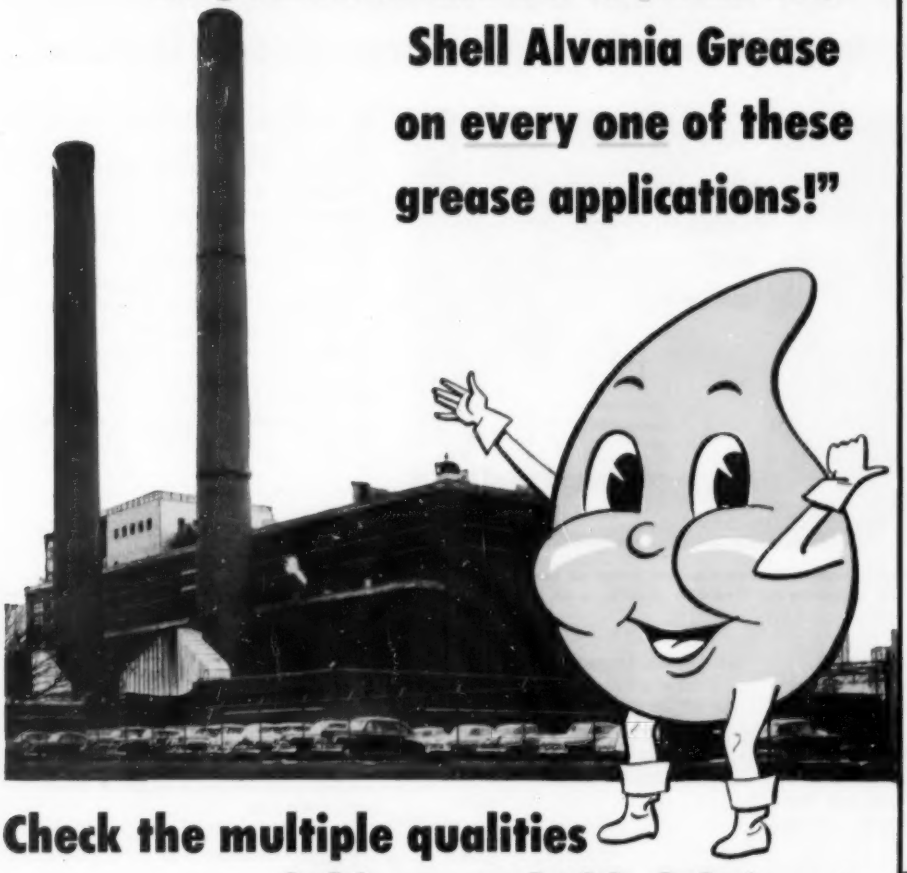

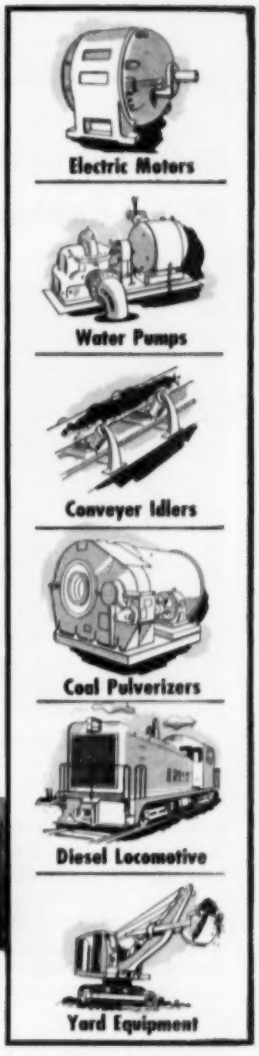

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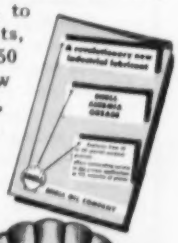

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REFERENCES

1. Bondi, A., Cravath, A. M., Moore, R. J., and Peterson, W. H., *NLGI Spokesman, 13*, No. 12, 12 (1950).
2. Farrington, B. B., and Davis, W. N., *Ind. Eng. Chem., 28*, 414 (1936).
3. Fitzsimmons, V. G., Merker, R. L., and Singleterry, C. R., *NLGI Spokesman, 16*, No. 4, 8 (1952).
4. Forster, E. O., and Kolfenbach, J. J., *NLGI Spokesman, 18*, No. 2, 8 (1954).
5. Freundlich, H., and Jones, A. D., *J. Phys. Chem., 40*, 1217 (1936).
6. Hotten, B. W., *Lubrication Engineering, 8*, No. 5, 244 (1952).
7. Hotten, B. W., and Birdsall, D. H., *J. Colloid Science*, 7, 284 (1952).
8. McBain, J. W., Bolduan, O. E. A., and Ross, Sydney, *J. Am. Chem. Soc., 65*, 1873 (1943).
9. Minerals and Chemicals Corp., Philadelphia.
10. Peterson, W. H., and Bondi, A., *J. Phys. Chem., 57*, 30 (1953).
11. Swakon, E. A., Brannen, C. G., and Brunstrum, L. C., *NLGI Spokesman, 18*, No. 1, 8 (1954).
12. Vold, M. J., Elersich, V. A., Baker, R. F., and Vold, R. D., *NLGI Spokesman, 18*, No. 5, 8 (1954).

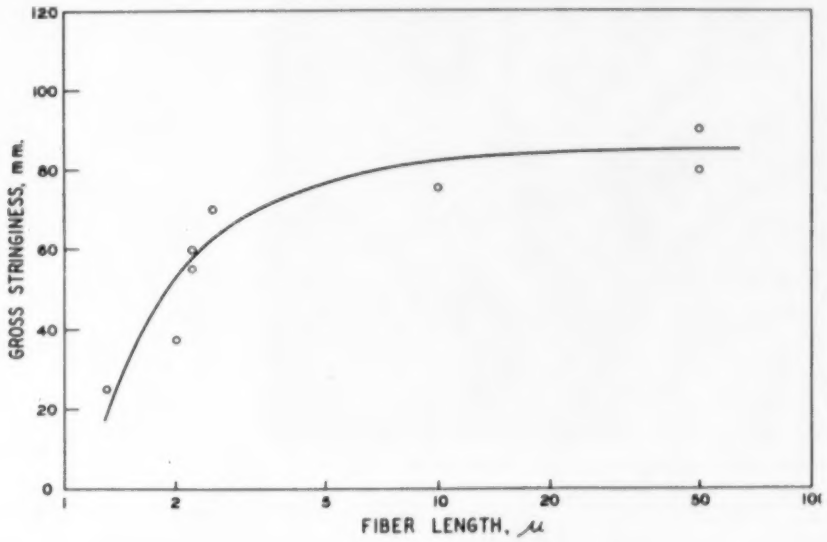

Figure 5. Effect of soap fiber length on gross stringiness.

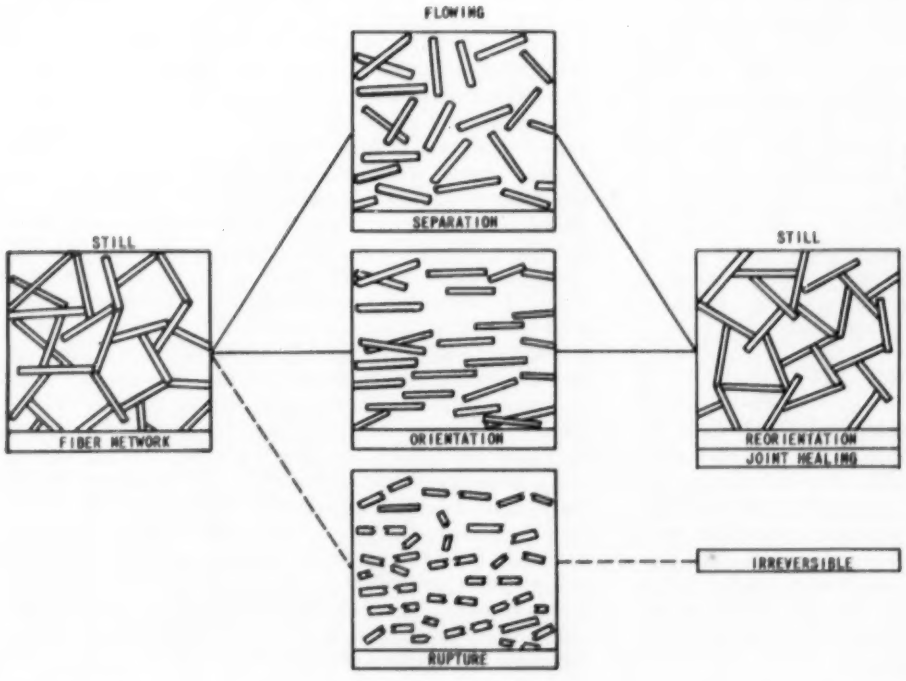

Figure 6. "Some effects of the 'Fours Ss' on a typical lubricating grease."

THICKENER PARTICLE DIMENSIONS*

Figure 1. A counting enlarger measures individual fibers by enlarging electron photomicrographs ten times.

ABSTRACT

Changes in the consistency of greases were investigated by means of the apparent changes in the thickener-particle sizes that occurred upon working and subsequent aging. Thirteen widely different greases showed correlations between penetration and-length-to-width ratio of the particles. In nine cases, the ratio decreased during working as the grease softened and increased during aging as the grease hardened. In the other four cases, the ratio again decreased during working as the grease softened, but, during aging, rapid hardening occurred independent of the ratio; after one to three months of aging, the ratio increased linearly as penetration decreased. These results suggest two distinct types of consistency change during hardening: (1) that arising from changes in particle shape, and (2) that arising from interparticle attractions.

Introduction

Lack of fundamental knowledge of the structure and rheology of lubricating greases forced grease making to develop as an art rather than a science. During the past decade, the physical nature of greases has been the subject of widespread study. The electron microscope has established that grease is a two-phase system.[1] Solid thickener particles randomly scattered through the oil phase give body to this system by holding the oil in the interstices, largely by capillarity. When the space between fibers becomes large, the oil-holding capacity decreases because the capillarity is reduced. So discrete is the thickener phase that the oil phase can be removed and replaced without destroying grease structure.[5] These concepts give a qualitative picture of the semisolid nature and flow peculiarities of greases.

Colloidal theory has improved the understanding of grease structure. A grease may be regarded as either a gel-like system with weak intraparticle forces or a sol-like system with weak interparticle attractions. Theoretical consideration of the flow of anisometric-sol systems have shown that the viscosity or consistency depends upon the length-to-width ratio of the constituent particles.[6] By comparing dispersions of nylon fibers in oil with greases of known length-to-width ratios (L/W), Bondi found that a correlation exists between L/W and consistency.[2] Interparticle attractions have been shown to be important in gel or pseudo-gel grease systems.[3] Thus, particle shape and interparticle attractions are important to grease consistency and flow behavior.

To investigate further the effect of thickener-particle shape upon lubricating-grease consistency, it was necessary to measure thickener-particle dimensions of greases of known consistency. Changes in particle dimensions that occur upon mechanical working and subsequent aging were measured from electron micrographs of the particles. These changes were correlated with consistency as measured by a penetrometer.

*Most of this work was done under contract with the Ordnance Corps, U. S. Army, Rock Island Arsenal.

and . . . Lubricating Consistency Grease

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Method

Thirteen greases composed of a variety of thickeners in oils of differing viscosities were studied. Table I shows the composition of these greases, which were limited to those of NLGI grades 0, 1, and 2. Greases made with the same soaps but in different concentrations were included.

TABLE I
Composition of Greases

Grease	Grade	Thickener Type	Thickener Wt. %	Oil Viscosity*
A	1	Sodium Soap	20	300
B	2	Sodium Soap	10	500
C	1	Calcium Soap	13	300
D	2	Calcium Soap (Anhydrous)	11	100
E	2	Calcium Soap (Anhydrous)	12	70
F	2	Lithium-Calcium Soap	12	80
G	0	Lithium-Calcium Soap	8	370
H	2	Lithium Soap	7	850
I	2	Lithium Soap	7	90
J	2	Lithium Soap	12	75
K	2	Lithium Soap	20	300
L	1	Non-soap, Organic	15	400
M	2	Modified Clay	8	1000

*Saybolt Universal Seconds at 100° F.

Equipment

Two types of machines for working the greases were used. An ASTM worker was operated according to Method D217-52T except that the 1/16″-hole plate was used. A roll-stability apparatus[8] was operated at 180 rpm with a 90-g. charge of grease. All working and aging was at 77°±2° F.

The proposed ASTM quarter-size-cone penetrometer[7] was used. A correlation curve determined for the instrument converted results to ASTM 150-g-cone penetrations. A uniform set of penetrometer cups, which also held the greases during aging, were made from glass specimen vials with an I.D. of 9/16″ by cutting to an inside depth of ¾″.

An RCA (EMU) electron microscope and a commercial shadowing apparatus were used in making the electron micrographs.

Procedure

Each grease under investigation was divided into three groups of 10 samples each. One group was placed in the penetrometer cups unworked. The second group was worked 60 strokes in the ASTM worker before being placed in the cups. The third group was worked four hours in the roll-stability apparatus and then put into cups. Penetration measurements were taken on a sample from each group after ten scheduled periods of aging over a span of three months. Extra care was taken to insure precise measurements.

At the same time that the penetration measurements were made, portions of the grease were observed in the electron microscope. Extremely thin films of grease were needed so that the individual thickener particles could be resolved. Specimens were prepared by a "printing" technique developed for this study and similar to that reported by Mottlau.[9] A thin film of grease was smeared on a microscope slide with a spatula. The grease on the slide was then brought into contact with a collodion film spread on the surface of clean water. A thin "print" of the grease was left on the film. A section of the film of suitable grease thickness was transferred to a screen, which was placed on another microscope slide and washed several times with n-pentane to remove the oil. The screen was shadowed at an angle of 15° with chromium by the technique of Williams and Wyckoff.[10]

Electron photomicrographs of each specimen were enlarged ten times to give a working magnification of 40,000. Fibers were individually measured as shown in Figure 1, and lengths and widths of each were tabulated. Wherever possible, at least 500 fibers were measured. Because the average length-to-width ratios ($\overline{L/W}$) and the ratios of average lengths to average widths ($\overline{L}/\overline{W}$) differed by less than 5% for the first seven greases studied, the more-easily determined $\overline{L/W}$ was used for correlation.

Discussion

The average ranges of size throughout the working-aging cycle are shown in Table II. All greases studied showed a relationship between penetration and $\overline{L/W}$. No general curve fitted the data for all greases, nor was there a relationship between thickener type or concentration and curves of $\overline{L/W}$ against penetration.

TABLE II

Average Size Ranges of Thickener Particles

Grease	$\overline{L}(m\mu)$ Min.	$\overline{L}(m\mu)$ Max.	$\overline{W}(m\mu)$ Min.	$\overline{W}(m\mu)$ Max.	$\overline{L/W}$ Min.	$\overline{L/W}$ Max.
A	500	750	36	41	14	19
B	2200	3200	130	150	15	25
C	730	1000	21	44	20	26
D	540	1200	30	37	17	35
E	650	810	26	29	24	30
F	1200	2400	38	68	26	40
H	1400	2000	64	84	18	28
I	450	750	37	66	11	18
J	1110	1700	60	100	16	32
G	210	310	24	32	7	11
K	120	430	28	30	4	14
L	330	520	50	110	3	9
M	440	640	25	45	9	19

In nine greases out of thirteen, a straight line seemed to best express the data. Figure 2 shows a typical curve. The $\overline{L/W}$ decreased during working as the grease softened and increased during aging as the grease hardened. The slopes and the range of $\overline{L/W}$ were different for each grease. Figure 3 shows a composite of the nine curves.

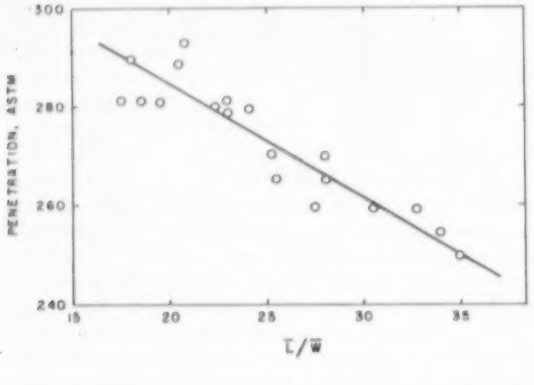

Figure 2. Typical curve of single stage hardening.

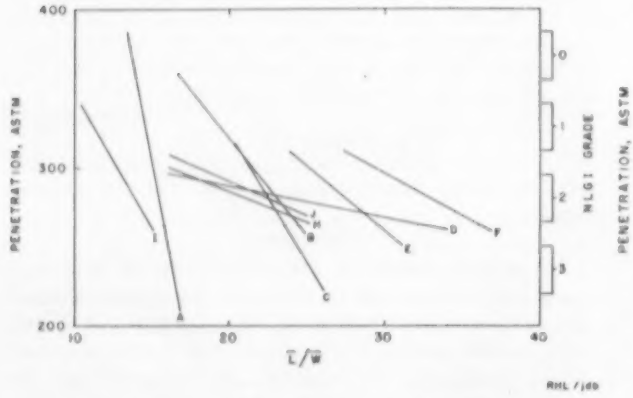

Figure 3. Nine curves of single stage hardening.

The remaining four greases showed a different phenomenon. Figure 4 shows an example of this group. During working, $\overline{L/W}$ again decreased as the grease softened, but, during aging, rapid hardening occurred independent of $\overline{L/W}$. After one to three months of aging, $\overline{L/W}$ increased linearly as penetration decreased.

The appearance of the thickener particles differed. An electron micrograph of a lithium-soap grease (H) that showed a direct relationship between $\overline{L/W}$ and penetration is shown in Figure 5. A micrograph of one (K) that showed two-stage hardening is shown in Figure 6. Nevertheless, the behavior of greases cannot be predicted from particle appearance alone.

The four greases that showed a measurable amount of hardening independent of $\overline{L/W}$ were also the most thixotropic. These greases had $\overline{L/W}$ ratios less than 15, whereas most of the other nine had $\overline{L/W}$ ratios greater than 15.

Other functions of particle dimensions—$\overline{L}$, $\overline{W}$, $\overline{LW^2}$, and $\overline{L^2W}$—did not correlate with penetration for all greases.

Conclusion

Two hardening mechanisms seemed to be controlling the consistency of the greases studied. Hardening for the nine greases that showed a linear relationship between penetration and $\overline{L/W}$ can be explained by the effect of particle shape. The rapid hardening independent of $\overline{L/W}$ can be accounted for by interparticle attractions. These attractions may also account for the difference in slope of the curves in which penetration depended on $\overline{L/W}$.

Significantly, the thickener particles showed an apparent increase in $\overline{L/W}$ during aging. This apparent fiber growth may be simply caused by a realignment of particles. The way in which an actual change in particle shape might occur is unknown, but one possibility is by solution and reprecipitation in which large particles increase in $\overline{L/W}$ at the expense of smaller particles.

The amount of working in these controlled tests is small compared to that which probably occurs in service.[4] Nevertheless, the difference between laboratory and service conditions should not affect the concepts revealed. Hardening by the same mechanisms would be expected also after more-severe working.

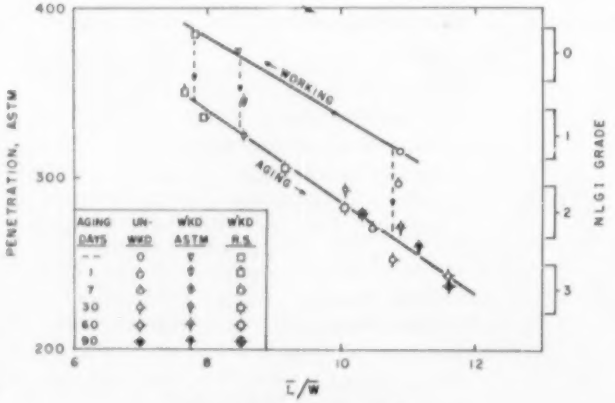

Figure 4. Two-stage hardening.

Figure 5. Thickener particles of lithium soap grease H.

Figure 6. Two-stage hardening of lithium soap grease K.

Acknowledgement

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LITERATURE CITED

1. Birdsall, D. H., and Farrington, B. B., *Inst. Spokesman, 11*, No. 1, 4 (1947); *J. Phys. & Colloid Chem., 52*, 1415 (1948).
2. Bondi, A., et. al., *Inst. Spokesman, 13*, No. 12, 11 (1950).
3. Bondi, A., in "Proceedings of the Second International Congress on Rheology," p. 274, New York, Academic Press, 1954.
4. Brown, J. A., Hudson, C. N., and Loring, L. D., *Inst. Spokesman, 15*, No. 10, 8 (1952).
5. Browning, G. V., *Inst. Spokesman, 13*, No. 12, 12 (1950).
6. Eisenschitz, R., *Z. Phys. Chem., 158A*, 78 (1932).
7. Hotten, B. W., and Kibler, G. M., *Anal. Chem., 22*, 1574 (1950).
8. McFarlane, R. P., *Inst. Spokesman, 6*, No. 12, 2 (1943).
9. Mottlau, A. Y., *J. Appl. Phys., 20*, 1055 (1949).
10. Williams, R. C., and Wyckoff, R. W. G., *J. Appl. Phys., 17*, 23 (1946).

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FORCES RESPONSIBLE for Lubricating Grease Structure

By

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Chemistry Department
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ABSTRACT

It is shown that London-van der Waals attractive forces between randomly crossed soap fibers in oil yield junction points adequate to account for the yield value and consistency of greases. A method is presented describing practical grease properties in terms of curves of total interaction energy as a function of particle separation. Phenomena such as shear breakdown, age and work hardening, and thixotropy depend on the existence of repulsive forces strong enough to exceed the attractive forces and create a potential barrier to the re-formation of ruptured junctions. Electrostatic repulsion, steric forces, and dipole repulsion provide possible sources for such a barrier. Their relative importance depends upon particle size as well as the chemical nature of oil and soap.

Introduction

This paper reviews recent additions to understanding the nature of the forces operative between colloidal particles in non-aqueous media with a view of assessing the applicability of the new ideas to grease problems.

For this purpose, the following idealized description of grease structure is employed. The ultimate particle of soap thickener, which is assumed to be unaffected by time or shear, except over long periods or at high shear rates, is an elongated lath-like crystal in which both lath surfaces are covered with the terminal methyl groups of the hydrocarbon chains, with the edges and ends containing rows of exposed metal carboxylate groups as indicated in Figure 1.* Dispersion into these ultimate particles is, however, not completed during grease manufacture so that the colloidal particles under consideration are aggregates of ultimate crystallites, more or less parallel along the fiber axis but rotated about it relative to each other by varying amounts. In a grease, these fiber bundles are disposed in as random a fashion as is consistent with their accommodation in the given volume. This packing automatically insures many fiber contacts and the familiar oil-retentive pore network. Bonds of varying strength bind the soap network together at the contact points and lead to a semi-continuous structure. The macroscopic grease is thought to comprise a close packed, more or less coherent assembly of these particle aggregates which together with their oil content have been called gel lumps by Bondi and Penther.[2]

The properties of the grease are described in terms of practical measurements while the properties of its components are characterized by simpler but less easily measurable quantities. The following partial listing of properties illustrates the distinction between "fundamental" and "practical" properties.

Quantative relations between the practical and fundamental concepts are not difficult to visualize. Thus, yield value is associated with rupture resistance of the weakest junctions in sufficient number to make flow possible. Consistency is correlated with rates of breaking and re-formation of junctions at the given shear rate† as well

†The correlation between consistency and the length/width ratio of fibers[3] is possibly due in part to the relation between these geometric characteristics and the number and spatial distribution of junction points.

Relation Between Practical Grease Properties and Fundamental Concepts

		Oil ↓	
Ultimate Crystallites →	Particles (often fiber bundles) →	Gel lumps →	Grease
Crystal structure	Size	Deformability	Yield value
Crystal habit	Shape	Size	Consistency
	Internal order	Mutual cohesion	Shear breakdown
	Rupture resistance	Mean life	Work hardening
		Pore size	Bleeding
			Age hardening
			Thixotropy

*Bondi and co-workers[1] have presented x-ray evidence that in sodium laurate the lath edges are hydrocarbon in nature and the faces striated with rows of polar groups. H. Scouloudi, working in our laboratories, has found by means of the same established technique that sodium-palmitate behaves as described and indicated in the drawing.

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as with oil viscosity. Shear breakdown is attributed to rupture of junctions which are unable to reform either because of high activation energy or highly specific orientation requirements. Chopping and shredding of fiber bundles is included under this heading. The converse, work hardening, is attributed to the increased likelihood of occurrence of the special orientations required to form these junctions whose strength may approach that of single crystals. Oil separation results from the increasing pore size accompanying reversion of the system to its equilibrium condition which in all cases is probably a large single soap crystal immersed in oil.

In this picture, the forces operative between soap particles in contact (or proximity) play an important role. Present theories describe four kinds of such forces with varying degrees of detail. These are London-van der Waals attractive forces, electrostatic repulsion of charged particles, dipole repulsion, and steric forces.

London-van der Waals Forces

This type of interaction, the universal attraction of atoms for each other which leads invariably to a net attraction of like particles in an isotropic medium, is to be calculated by evaluating the sum of λ_{ij}/r^6 over all the separate atoms in both particles and subtracting the sum of λ_{mn}/r^6 for atoms of solvent molecules that would be in the given positions if the particles were separated. Here λ_{ij} or λ_{mn} is an interaction constant depending on the chemical species in an atom pair and r is their separation. The experimental work of Overbeck and Sparnaay[11] provides direct verification of the postulated additive property of this type of interaction.

In making calculations for soap particles suspended in oil, it is necessary to take into account the circumstance that the fibers do not have cylindrical symmetry. When two fibers cross each other, the relative orientation of the lath surfaces will thus affect the resulting interaction. To the extent that the fibers are more like laths than square rods the orientation shown in Figure 2a with lath surfaces in proximity will be more common than that illustrated in Figure 2b in which lath edges are faced toward each other.

In either case the magnitude of the attractive energy can be calculated by the formula[12]

$$V = \Sigma \frac{A_{ij}\, a}{12\pi} \left[\frac{1}{d_{ij}^2} + \frac{1}{(d_{ij} + 2t)^2} - \frac{2}{(d_{ij} + t)^2} \right]$$

in which A_{ij} is a constant taking into account the difference in van der Waals interaction of atoms in the $_i$th and $_j$th layers of the two fibers and atoms of the oil molecules that would replace them when the fibers are separated. d_{ij} is the separation of the $_i$th and $_j$th layers and t the thickness of the layers into which the fiber is divided for calculational purposes. A_{ij} can be taken as zero for carbon-carbon interactions. a is the overlap area of the two crossed fibers. The formula is valid for long fibers crossed at angles not differing greatly from 90°.

For two contacting fibers with lath faces opposed (Figure 2a) the principal contribution comes from the closest layers of oxygen and metal ions which are 4-6 Å thick and held apart by the hydrocarbon chains at a dis-

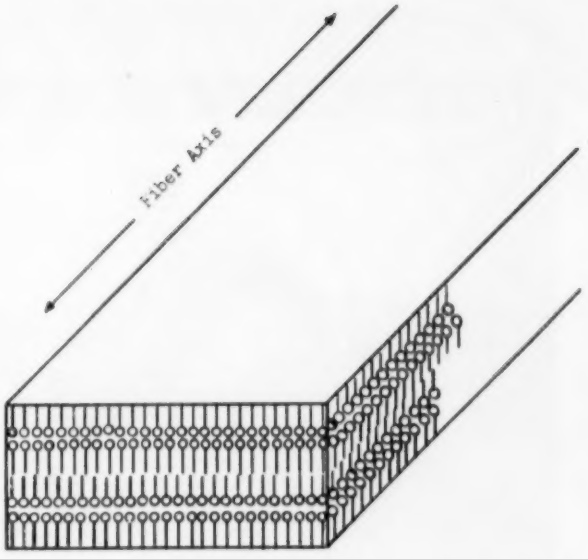


FIGURE 1

Probable Disposition of Soap Molecules in a Soap Fiber

This arrangement in which the largest surface is covered with hydrocarbon groups and ends and edges contain exposed polar groups has been demonstrated directly for sodium palmitate and indirectly for lithium and calcium stearates but is not valid for sodium laurate.

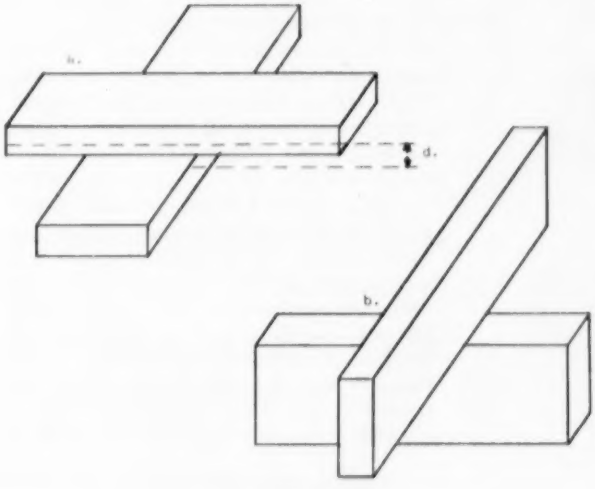
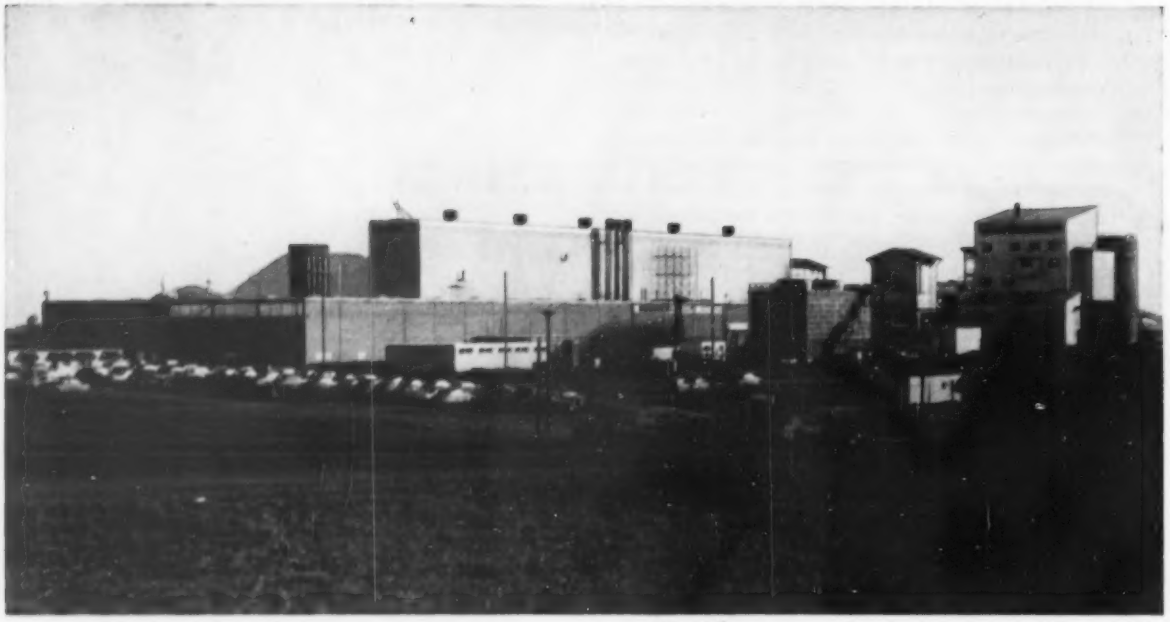


FIGURE 2

Configurations in the Random Crossing of Two Soap Fibers

In case a., lath surfaces are in contact but the first layers of metal and oxygen atoms which contribute most heavily to the London-van der Waals attraction are separated by a distance d. which is about twice the length of the hydrocarbon chain. In case b. the polar groups are exposed on the contacting edges leading to a much stronger junction.



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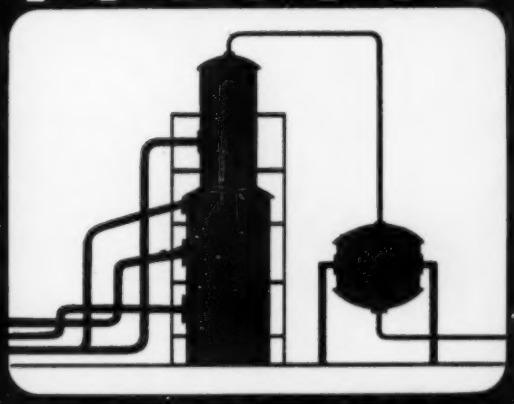

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tance of 35-50 Å depending on the chain length of the soap. Using the reasonable values of $0.1\mu^2$ for the fiber width and 10^{-12} for A, substitution yields for the interaction energy.

$$V = \frac{10^{-12} \times 10^{-16}}{12\pi}\left[\frac{1}{50^2} + \frac{1}{(50+10)^2} - \frac{2}{(50+5)^2}\right]$$
$$= 4.3 \times 10^{-13} \text{ ergs}$$

This energy is roughly ten times larger than the thermal energy of the colloidal fibers so that such contacts are strong enough to account for the rigidity of unworked greases. Moreover the strength of such a junction and consequently the yield value of the grease increases with decreasing soap chain length.

A rough estimate shows that junctions of this strength can readily be broken by shearing. With an oil viscosity of 100 cs and a shear rate of 5000 reciprocal seconds the shear stress is 5000 dynes/cm² and acts over an area of the length times the width of the fiber in a favorably oriented case of $1 \times 0.1\mu$ or 10^{-9} cm² to give a disruptive force of 5×10^{-6} dynes. The attractive force calculated for the junction of Figure 2a by differentiating the energy with respect to distance is 3×10^{-6} dynes.

Fiber junctions of the type shown in Figure 2b in which close approach of the polar groups is not restricted by interfering hydrocarbon chains are likely to be much stronger but the calculation now needs to take short-range repulsive forces into account. These junctions may be strong enough to resist rupture except at very high rates of shear. Once free of each other the polar surfaces of the soap fibers are apt to become covered with an absorbed layer of the more polar of the oil molecules. They can join together again only during the infrequent moments when both members of a close lying fiber pair are temporarily bare. Thus, re-formation of such junctions after rupture is slow and their rupture under high shear can contribute to shear breakdown‡.

Over long periods of time and particularly during moderate working, the opportunity for the formation and perfection of such bonds can result in the phenomena of age and work hardening. Lack of tenaciously adsorbed oil molecules to block sites for formation of such junctions may contribute to the instability of soap gels in highly refined, high viscosity index paraffinic oils.

Potential Energy—Fiber Separation Curves for Greases

The device of discussing the stability of lyophobic colloids in terms of curves giving the total mutual energy of two particles as a function of their separation, particularly with the quantitative calculations of Verwey and Overbeck,[12] has been so successful that it is tempting to use the same kind of approach to describe the behavior of greases.

Schematic curves are shown in Figure 3. The minimum value is put at -10 kT in accord with the calculated strength of the junctions between randomly crossed fibers. The height of the potential barrier which must be surmounted when junctions are made or broken is also important. If the barrier is low or absent as in curve C of Figure 3, junctions will reform almost every time two fibers come close to each other and the grease will be non-thixotropic, time-stable and not subject to shear breakdown so long as the shearing stress is not high enough to cause extensive fiber breakage. If the barrier is high, as in curve A, shearing will still be able to cause junction breakage and reduced consistency but the junctions cannot form again and the loss of body is permanent. If the barrier is of intermediate height reformation of ruptured junctions occurs at a measurable rate yielding a thixotropic system.

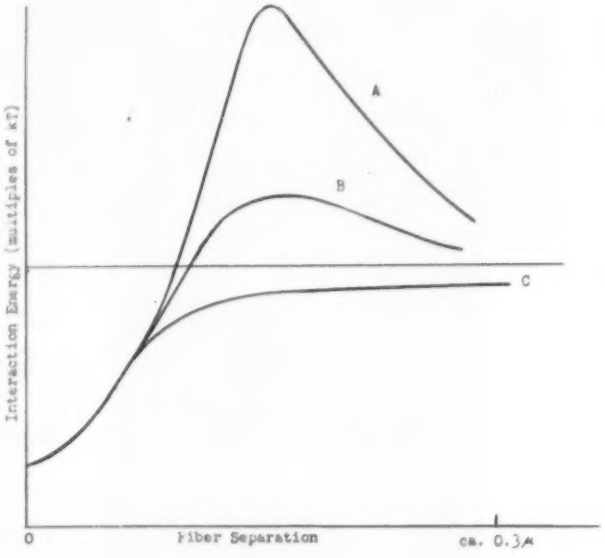

FIGURE 3

Schematic Potential Curves for Soap Junction Points in Greases

Rheological properties may be related to the rates of breaking fiber junctions (passing from left to right along the curves which can occur at moderate shear rates even if a barrier exists) and junction formation (passing from right to left along the curves). This would be slow for grease A which would thus be unstable to working, moderate for grease B which would be thixotropic, and rapid for grease B which thus represents a stable grease.

Further elaboration of this way of describing grease behavior requires a means of estimating the repulsive forces to combine with the estimates of London-van der

‡The union between parallel fibers in a fiber bundle is also hard to rupture and slow to reform because of the special orientation required. Fiber shredding which changes the number of contact points and fiber breakage which reduces the size to which gel lumps can grow are also likely to be important in shear breakdown.

Waals attractive forces in evaluating the height of the potential barrier.

Repulsive Forces

There are three possible sources of mutual repulsion between colloidal particles in an oil medium. Quantitative evaluation for soap particles in a grease has not yet been done for any of them so that the present discussion is quite speculative and serves principally to point out a potentially useful direction for new research.

First is the possible existence of free electric charges on the soap fibers. The existence of such charges on colloidal carbon in oil has been demonstrated by van der Minne and Hermanie.[7,8] Charges can accumulate on soap particles only to the extent that counter-ions to yield electrical neutrality can be accommodated in the oil medium. These counter ions are usually considered to be molecule-ion pairs or small micelles. It follows that dissociation of negative soap ions from a soap fiber leaving a net positive charge should occur more readily with more soluble soaps. This should lead to a softer, more thixotropic and more shear sensitive grease which is more or less in accord with experience. Oil soluble salts may exert their liquifying action on greases by inducing electric charges on the soap particles in some such fashion. The presence of charges on the growing fibers during grease manufacture at temperatures where the soap solubility is still appreciable may contribute to control of final fiber dimensions by restricting aggregation.

The soap fibers also contain sheets of metal ion-oxygen dipoles which are oriented to produce repulsion in all configurations of the fibers with respect to each other. Van Olphen and Ginzbarg have calculated the magnitude of this effect for bentonite in water and found it small, but it may be larger for greases. Since its magnitude will in any case be proportional to the dipole moment per unit area it should be smallest for lithium greases whose small ion can be sucked in closer to the carboxyl oxygens of the soap structure.

Finally the steric effect found by Mackor, van der Waals and van der Waarden[5,6,14] to be important in stabilizing carbon suspensions in oil by long chain aromatics is deserving of consideration. The idea here is that the chains on an isolated particle are able to oscillate freely in the medium but in order to bring two particles close together the chains appended to them must be carefully packed together which involves doing a calculable amount of work on the system related to the decrease in entropy of the ordered over the disordered chain arrangement. The chain appendages to the soap fibers necessary for this effect can occur at the frayed ends of fibers and wherever polar bodies from the oil are adsorbed on the fiber surfaces.

In order to be significant in determining the behavior of a given grease these repulsive forces must exceed the attractive forces by a substantial margin compared to thermal motions at moderate fiber separations thus creating the barrier portion of the schematic curves of Figure 3. Koelmans and Overbeck[4] have shown that which of them is important in stabilizing a given suspension of pigment particles in xylene depends critically on particle size. Their reasoning can be applied qualitatively to greases.

For a given surface potential the electrostatic repulsion due to free charges increases with fiber diameter. For large spherical particles ($>1\mu$ in diameter) it can be enough larger than the London-van der Waals forces to produce a sizeable potential barrier. Therefore, it can be expected that coarse-textured greases will be more sensitive to charge inducing variables (soap solubility, oil soluble salts) than fine textured greases in which electrostatic repulsion is never greater than London-van der Waals attraction. The converse is true for steric forces. These are negligible at separations greater than the chain length of adsorbed molecules (ca 40 Å for 20 Å chains on each particle). At these small separations the attraction between large particles is already too large for steric forces to exceed it and create a potential barrier. Thus it is fine textured greases which should be most sensitive to the presence of polar bodies in the oil. The dipole repulsion, being primarily an edge effect, increasing with increasing perimeter to area ratio of the dipole covered surfaces is also apt to be more important for small fibers than for large ones.

Acknowledgement

The author wishes to express her indebtedness to R. D. Vold and J. Th. G. Overbeck for helpful discussions of the ideas submitted in this paper and to the John Simon Guggenheim Memorial Foundation for financial support.

REFERENCES

1. Bondi, A., et al, *Proc. 3rd World Petr. Congr.*, Sec. VII, 373 (1951).
2. Bondi, A., and Penther, C. J., *J. Phys. Chem.*, 57, 72 (1953).
3. Farrington, B. B., and Birdsall, D. H., *Ann. N. Y. Acad. Sci.*, 53, 979 (1951).
4. Koelmans, H., and Overbeck, J. Th. G., *Faraday Soc. Symp.*, Sept., 1954.
5. Mackor, E. L., *J. Coll. Sci.*, 6, 492 (1951).
6. Mackor, E. L., and van der Waals, J. H., *J. Coll. Sci.*, 7, 5 (1952).
7. van der Minne, J. L., *Rec. Trav. Chim. Pays-Bas*, 65, 549 (1952).
8. van der Minne, J. L., and Hermanie, P. H. J., *J. Coll. Sci.*, 7, 600 (1952) and *ibid*, 8, 38 (1953).
9. Moore, R. J., and Cravath, A. M., *Ind. Eng. Chem.*, 43, 2892 (1951).
10. van Olphen, H., *2nd Nat'l. Clay Comm. Mt'g.*, Columbia, Mo., Oct. 17, 1953.
11. Overbeck, J. Th. G., and Sparnaay, M. J., *Faraday Soc. Symp.*, Sept., 1954.
12. Verwey, E. J. W., and Overbeck, J. Th. G., *Theory of the Stability of Lyophobic Colloids*, Elsevier, 1948.
13. Vold, M. J., *J. Coll. Sci.*, (accepted for publication).
14. van der Waarden, M. J., *Coll. Sci.*, 5, 317 (1950); *ibid*, 6, 443 (1951).

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Condensation of DISCUSSION

By

A. BONDI

Shell Development Company
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The discussion was very lively, as one might have expected with a subject in which all of the participants were so actively engaged. The session was terminated only by the need to leave some time for the traditionally festive social affairs of the Annual Meeting.

So many valuable points were made during the discussion that the editors of the symposium decided to print a condensed version of the transcript* together with the papers.

On re-reading the transcript, one can clearly discern three main streams of thought: (a) the role played by the forces between particles in holding the grease structure together, (b) the validity of the structural information which one obtains from the electronmicroscopist and from other sources, and (c) the meaning of the observed structures in terms of grease properties and performance. The following review will cover these points in the order given.

At the outset of the discussion, Mr. Bondi remarked that from the point of view of the physicist a macroscopic system can be considered as well understood if its properties can be described in terms of the geometry of its constituent particles and the forces which act between them. The colloid physics of lubricating grease appear to approach this happy state now that the extensive information regarding the gel particle geometry is beginning to be supplemented—through Mrs. Vold's interesting paper—by an inquiry into the forces which hold the network together. He said, however, his own calculations had convinced him that only those soap fibre junctions contribute in an important manner to the gel strength which are of the same strength as the soap fibres themselves. In his opinion, the main contribution of Hamaker's London-van der Waals forces, invoked by Mrs. Vold, is that they provide the force to create the fibre junctions, and specifically they are responsible for the rapid healing of sheared junctions in the particle network. In the absence of these forces, a grease would not survive a single bearing revolution. For example, the separation of two typical grease fibres ($0.05 \times 1.0\ \mu$) by $1\ \mu$ in an oil of 1 poise viscosity would be followed by reformation of a fibre junction only after several minutes to hours if one had to rely on Brownian motion; but the junction will actually be formed anew in less than 10^{-3} sec owing to the action of the forces described by Mrs. Vold.

Mr. Steinbruch noted that these interparticle (by nature intermolecular) forces are the dominating factor in the preparation of inorganic base greases, where particle geometry is only of minor importance. The maintenance of properly balanced "dispersion" which was mentioned by several panel members is†, of course, largely a manifestation of the extent to which interparticle forces are screened by adsorbed layers of oil constituents or of deliberately introduced surfactants. That these adsorbed layers affect also the consistency of soap greases had been demonstrated in ref. (26) of the symposium paper by I. E. Puddington.

The complexity of the grease gel system and the softness of its components leads to recurrent questioning of the validity of the "facts" observed in the electron or the optical microscope because occasionally one is led astray by artifacts which have been created by the sampling procedure or by the process of examination. Another question which agitates the grease investigator is the applicability of x-ray diffraction to grease studies. Mrs. Vold answered the latter question by saying that x-ray diffraction patterns of greases can serve only to assist in the chemical identification of the soap-constituents and to show that the soap in the grease gel is probably identical in structure with the soap in a macroscopic crystal. Useful x-ray information regarding the internal structure of soap crystals could be had only from work on single crystals of pure soap specimen. Here, a very recent result on calcium stearate crystals indicates that—in contrast to the picture reported for alkali metal soaps

*The editors are indebted to the panel members and the discussants from the floor for kindly correcting the transcript of their remarks.

†Assuming that the average particle size is sufficiently small.

–the layers of the soap molecules are displaced parallel to the carbon chain by about ⅔ of the chain length. The resulting lack of clearly defined cleavage planes may account for the well known reluctance of individual calcium soaps to form fibres.

Electronmicroscopy is still the primary tool for grease structure investigation, as is evidenced by the fact that more than three-quarters of the discussion was devoted to this subject. Techniques of specimen preparation, upon the correctness of which the usefulness of the observation depends, came in for a thorough airing. Miss Artel reported that–judging by the comparison of the consistency of greases before and after freezing–the freeze contraction in crystallizing oil media does not appear to cause irreversible damage to the grease which they have investigated. They therefore feel that the (rather delicate) low temperature ultra-thin sectioning technique may have given representative pictures of the structures of their model grease gels. Others still report great difficulties with this technique.

As an example of typical identification difficulties, Mr. Leet cited the "typical" spiral or twist pattern of lithium 12 hydroxystearate soap fibres. His shadowgraphs reportedly indicate a twist if the fibres lay parallel to the chromium deposition, but only a ruffling of the edges when perpendicular to the chromium deposition. Several members of the panel felt that the twisting, actual or apparent, is not an inherent property of these fibres, but is produced during the preparation by shearing of the grease, etc. But in the case twisting be proven an inherent property of these soap crystals, Mrs. Vold and Mr. McClellan offered as tentative explanations of the phenomenon the effects of asymmetrical distribution of polar groups and of spiral dislocations in the crystal growth, respectively.

The aerogel technique of specimen preparation was recommended as a particularly suitable leaching technique by Messrs. Brunstrum and McClellan. Mr. Amott mentioned that the fibrillar fine structure of the soap fibres in certain barium and lithium greases is distinctly visible only when the unwashed grease is examined directly in the electronmicroscope. The solvent washed specimen do not exhibit any fine structure. Other panel members have, however, been quite unable to obtain useful results with unwashed specimen.

The serious doubts about preparation technique and the interpretation of electronmicroscope observations which came to light in this discussion might give the impression that the method is still in its infancy. This conclusion is contradicted by the very valuable insight into grease structure behavior which electronmicroscopy has already provided to date. This apparent contradiction leads to the conclusion that the preparation of electronmicrographs of lubricating grease structures is not a routine matter but a research investigation requiring skillful adaptation of the technique to the particular objects and objectives at hand.

Mr. Barnett had led off the panel with a series of stimulating questions, several of which pertained to the "practical" meaning of the observed grease structures. While it turned out that one cannot, in general, predict from an inspection of electronmicrographs what the properties of a grease are going to be, T. G. Roehner pointed out that the electronmicrograph will show structure differences between supposely identical production batches which–in the light of accumulated experience–permit a decision between good and bad performers for a specific service. The amount of time saved by not having to wait for a performance test may in such cases be considerable.

However, grease performance in most services depends on many properties, to which the initial structure is intrinsically unrelated. The few properties to which the observable particle structure seems to be directly related are in the opinion of most panel members: the instantaneous consistency (for a given type of gelling agent), and the bleeding tendency. Quality judgments on the basis of grease structure pictures are possible only in the light of the previous history of the specimen. This was emphasized by Mr. Barnett in connection with the interpretation of used grease samples. Professor Vold summarized the situation very well by saying that the evaluation of gel particle structure had now become a normal *part* of any serious grease investigation. In combination with the usual physical and chemical property data, the structure information now gives the grease research man the basic insight for the rational pursuit of his goal: a better lubricating grease!

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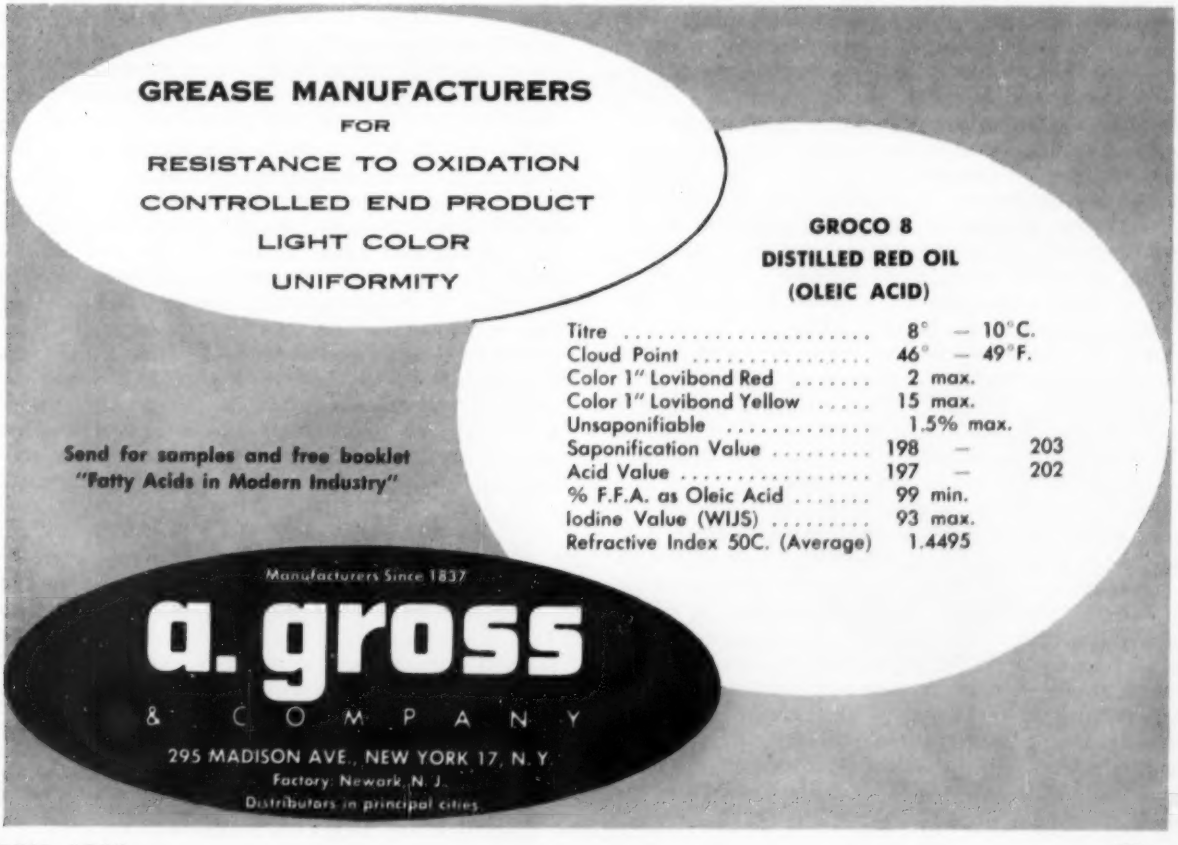


Dr. Buri measures various qualities of grease with the 3-Ball Tester

A New Method of GREASE TESTING

By

DR. A. F. BURI

Adolf Schmids Erben, Inc.

Berne, Switzerland

INTRODUCTION

In recent years, the development of new lubricating greases has taken a sensational upward course. The cause of this improvement is the application of new and better soap species, inorganic gelling agents, organic gelling agents other than soaps, better refined oils and new and efficient production processes. In the past, it was possible to predict the degree of utility of a lubricating grease by a critical consideration of a few chemical and physical laboratory tests. Today, the situation has changed entirely. In the field of roller bearing greases it is nearly impossible to predict the utility of a given product by means of these classical methods only. This is quite understandable if we consider the variety of factors influencing the stability of lubricating greases, especially roller bearing greases, in industrial application. Quite apart from the factors of chemical structure, oxidation by air, operation temperature, humidity of the air or even of water contamination, we have to consider mechanical working in the bearing, which is a function of bearing dimensions, speed and pressure. These factors all operate simultaneously, rendering an analytical prediction of the performance of a lubricating grease still more difficult. Taking into consideration these difficulties, producers of lubricating greases have developed new and additional tests for these lubricants.

Efforts in this direction, pioneered by the simple ASTM grease worker (ASTM Method D 218-48), in which only the change in penetration by working the grease with a perforated plate is measured, have been followed by complicated and expensive testing machines, in which the reactions of the various grease types applied to a number of bearings operating under various controlled conditions, are determined. In these procedures, not only is the resistance to working of a lubricating grease ascertained, but oil bleeding, evaporation loss and frictional characteristics as well. A few of these methods are CRC Designation L-24-745, ASTM methods published in the Special Technical Publication No. 84, ASTM Method D 1263-53T, Shell roller test, and the SKF test for roller bearing greases. It is not intended to enumerate here all existing test methods, but the above illustrate the complexity of the problem. To date, no universally accepted test method has been developed. In most cases, the inexpensive equipment so far developed measures only one characteristic, such as working resistance, at a time; whereas, oil bleeding friction and other factors necessitate additional tests. Other test equipment—and this concerns especially newly developed types—permit various characteristics to be obtained in a single test, but these machines generally are very expensive.

The new RIV* 3-ball grease tester, described more fully in the following pages, has been found, however, to be economical, yet it permits the collection of a number of data at the same time. Thus, the following characteristic qualities can be measured in one test: working resistance (breakdown resistance), frictional properties, resistance to temperature, film strength, and oil separation at various rotation speeds; with additional instrumentation these properties can be be measured at various temperatures as well. The test requires only a few hours and only a small quantity (100 to 150 g) of the material to be tested are needed. No costly instruments and complicated installations are necessary. In this test the action on the lubricating grease is the same as in a roller bearing.

Description of the 3-Ball Tester

The construction of the apparatus is illustrated by Figures No. 1 and 2. The apparatus consists of a round, flat cup, (1), the interior surface of which is polished, (2). This cup is supported by a vertical pivot located in the pedestal, (3), and mounted in two ball bearings in the supporting base, (4). Three balls, (5), of exactly equal

ACKNOWLEDGEMENT

*RIV—Officine die Villar Perosa, Soc. per Azioni, Torino is the inventor of this testing machine. I wish to take this occasion to thank this company for their kindness in supplying me with designs and construction drawings of this tester.

diameters that fit perfectly in the groove are placed in the cup. The three balls are kept 120° from each other by means of a brass cage, (6). The dimensions of this heavy cage are quite large, because it not only separates the three balls but, unlike conventional bearings, it drives the whole assembly. In addition, this cage has to absorb all the forces created by the rolling of the balls in the groove and on the sides, as well as by the resistance of the inserted grease. The horizontal center plane of the cage, defined by the three holes of the cage, lies below the center of the balls. Thus, the balls not only rotate about the principal vertical axis and roll tangentially on the sidewall, but, in addition, rotate about their own horizontal axis.

In order to fix the balls in the cage and to prevent the inserted grease from accumulating on top of or in the upper part of the cage, three small shields, (7), are fixed above the three holes, (8), of the cage. The whole cup is closed by a cover, (9), which is fastened by means of three screws, (10), to the solid base. In the cover there is a pivot, (11), supported on roller bearings and to which the cage is attached on one side with a screw; on the other side are two big vee-belt wheels, (12), of different diameters. In the pivot there is a groove, (13), for insertion of a thermometer.

The cup turns freely on the base of the apparatus. Its movement is restricted, however, by a bolt, (14), which contacts a spring, (15). Depending upon the resistance of the grease and the combined friction of the different parts of the apparatus, the cup turns in the direction of movement until the tension of the spring equals the frictional force.

The movement of the spring until equilibrium is established is recorded by a comparator, (16), the contact pin of which is located between the contact of the cup and the fixed lower end of the spring. By this means, the rational movements of the cup caused by the resistance are recorded exactly and proportionally. This recording gives the resultant of all the single resistances which can be divided into at least two components, the resistance met by the balls and the cage in the course of their movement, which at a given speed is constant and independent of the lubricating grease, and the resistance of the lubricating grease. As the first part represent an apparatus constant, it is easy to ascertain the resistance of any lubricating grease used.

If it is only desired to show the variation of grease consistency at different rotational speeds and for varying running times and to record changes of temperature, the cup can be fixed to the base, (17), so that it cannot move. The measurement of resistance is thus excluded. The temperature can be measured either in the drive pivot, (13), or by means of a mercury thermometer, (19), inserted in a tube fixed to the side of the cup, (18). It is, of course, possible to measure and record temperature continuously by electrical means.

The whole rotating part, i. e., cage, axis and the two vee-belt wheels, is driven by a vee-belt, (20), under tension, attached to an electric motor, (21). The measurements are usually made at two different rotational speeds, namely 300 rpm and 600 rpm. The speeds can be changed from one to the other by moving the vee-belt from one wheel to the other.

Test Procedure

The test procedure is as follows: 100 g. of grease are inserted in the groove of the cup without additional working with the spatula. The three balls are then placed in the greased cup at 120° from one another, the cage is inserted and the apparatus closed. Before the test starts, the cup is rotated until the small bolt touched the spring and the comparator is brought to zero. Care must be taken not to create a tension in the spring, in order to prevent an error in the resistance measurement. The thermometer is inserted and the test started at 300 rpm.

Comparator and thermometer readings are taken every five minutes during the first half hour of the test, and every 15 minutes up to three hours, after which the machine is stopped. A small sample of the grease is taken under test for micropenetration (consistency). In the second part of the test, the grease taken for the consistency test is put back into the apparatus. The test is allowed to run for another three hours, but this time at 600 rpm. The comparator and thermometer readings are carried out at the same intervals and in exactly the same

Figure 1. The 3-Ball Tester

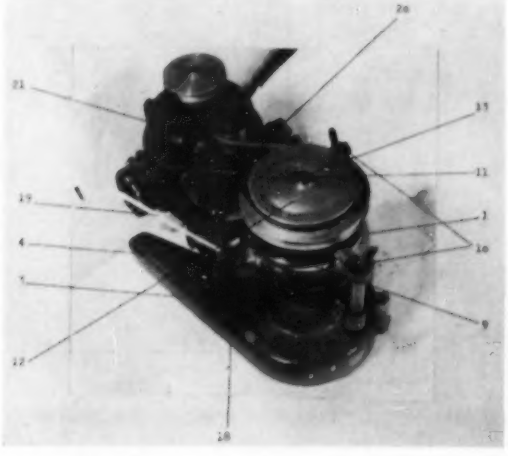
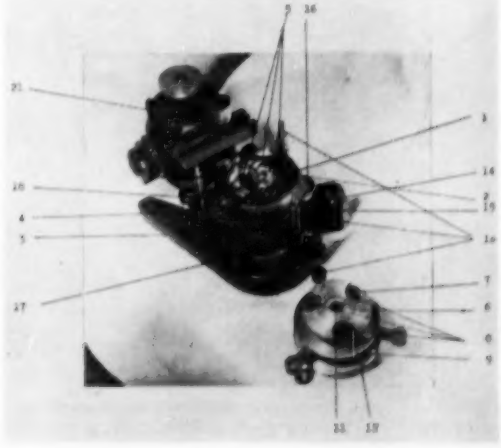


Figure 2. Inside view of cup and cover showing pivot and vee-belt wheels



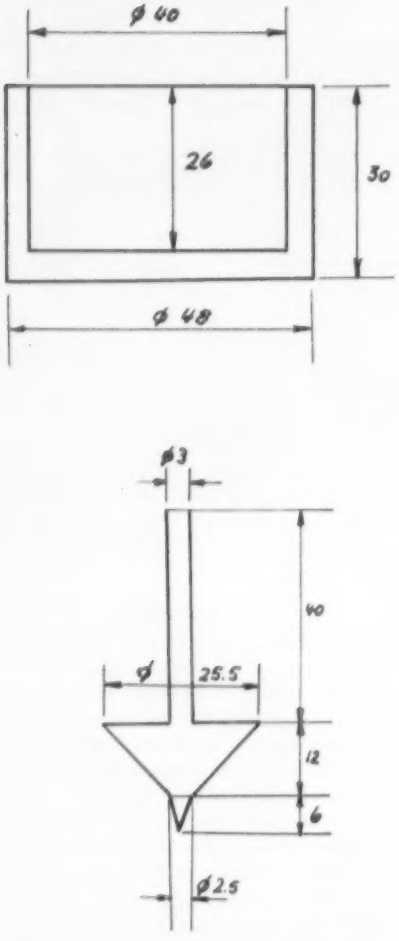


Figure 3. "A microcone measures consistency of inserted lubricating grease" Unit of measure—millimeters

way as in the 300 rpm test. Again a small grease sample is taken for micropenetration.

The data obtained in this test can be divided into three categories, all of which are important for the qualification of a good lubricating grease:

1. Change of the consistency with speed, time and temperature
2. Change of temperature with time and speed
3. Change of resistance to friction with speed, time and temperature.

Binary diagrams (consistency-temperature, consistency-resistance to friction, resistance to friction-temperature) or ternary diagrams (e. g. consistency-resistance to friction-temperature) can be established.

Test results on commercial greases of good reputation and known qualities give us a background against which to measure the reactions of a newly developed grease.

The older model 3 ball tester is not as resistant to friction. Test runs are made at 350 and 700 rpm and samples of 150 g. instead of 100 g. of grease are used.

Measurement of Micropenetration

It is necessary to employ a microcone for the measurement of consistency of the inserted lubricating grease because relatively small portions of grease are taken for this measurement and have to be brought as quickly as possible to a standard temperature of 25°C in a water bath.

The measurement is done in the usual fashion. The grease is put into a round container which is then placed for one hour in a water bath at 25°C. The penetration of the microcone into the grease is then measured according to ASTM Method D 217-52T, i.e. penetration measured in tenths of a millimeter during five seconds. The dimensions of the microcone are given in Figure 3. The total weight of cone shaft and microcone must be 64.5 g. The conversion of the microcone results into the

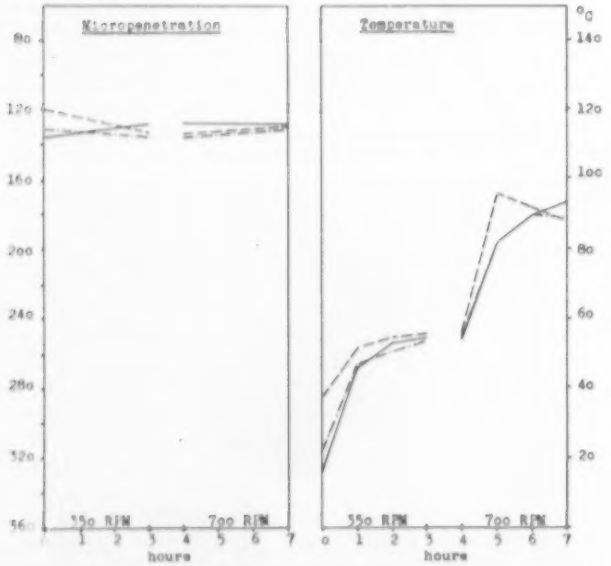


Figure 4. "Time consistency diagram and corresponding time-temperature plot resulting from sodium soap grease test"

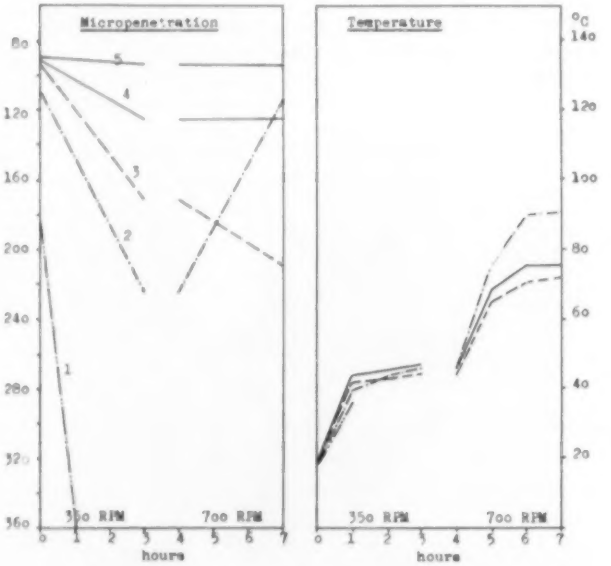


Figure 5. Test results of several unknown greases

ASTM scale is made with the help of tables, which depend upon the type of soap used in the grease.

Results Obtained with the 3-Ball Tester

The 3-ball tester furnishes data which can best be shown graphically, as in Figure 4. On the left, is a time-consistency diagram, and on the right, the corresponding time-temperature plot. It is clear that other relationships, such as resistance to friction-time, and resistance to friction-temperature, can be shown in similar fashion. Thus, each grease can be described by a few specific diagrams. The 3-ball tester can be used with good results for checking grease production, as well as for research and development.

Checking Production

The best procedure in measuring production is to draw a number of random samples from a batch. The various samples are then mixed together and a sample of 100 g. or 150 g. inserted in the 3-ball tester. Figure 4 is a diagram illustrating results for a sodium soap grease compared with a standard. Variations should not occur and cannot be tolerated.

Research

The possibilities of the 3-ball tester for research work are manifold. In this field, we are usually dealing with new, unknown grease compositions, and we do not know, as a rule, the qualities and reactions of such a newly developed grease. With the 3-ball tester, we obtain in a short time indications which otherwise could only be obtained by long and costly experiments. With the experience growing from extended use of this apparatus, certain diagram forms can be recognized and the respective conclusions drawn. Thus, the search for new grease components is made much easier. The best procedure is to manufacture a sample of 500 g. of lubricating grease according to the new formula. Part of the sample is then analyzed by the usual laboratory methods. Another part, however, (150 g. or 100 g., respectively) is inserted into the 3-ball tester. Typical results to be expected appear in Figure 5. These particular tests were carried out on four lithium greases which were manufactured with various grease bases, but by the same procedure.

Results were as follows:

Grease No. 1 liquified so quickly that the test had to be terminated before the allotted time.

Grease No. 2, after an initial decrease in consistency, stiffened at the higher speed. From the temperature-time diagram we see that this effect is accompanied by a considerable increase of temperature. Such greases are clearly affected by speed, but can be used without hesitation in roller bearings.

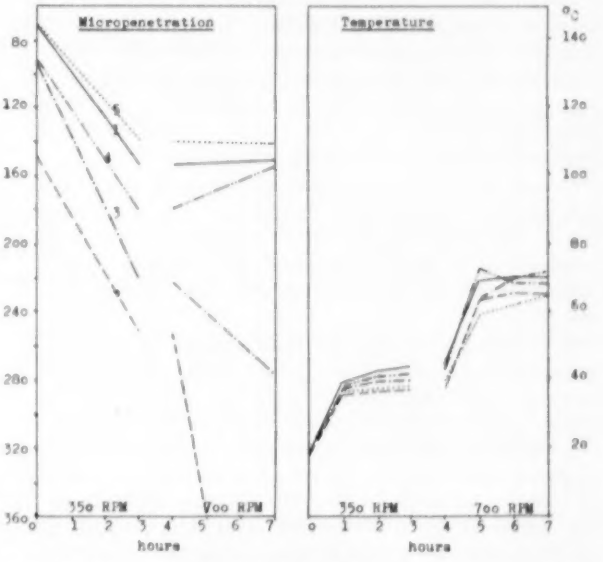


Figure 5. "How saponification time affects the properties of a lithium base grease"

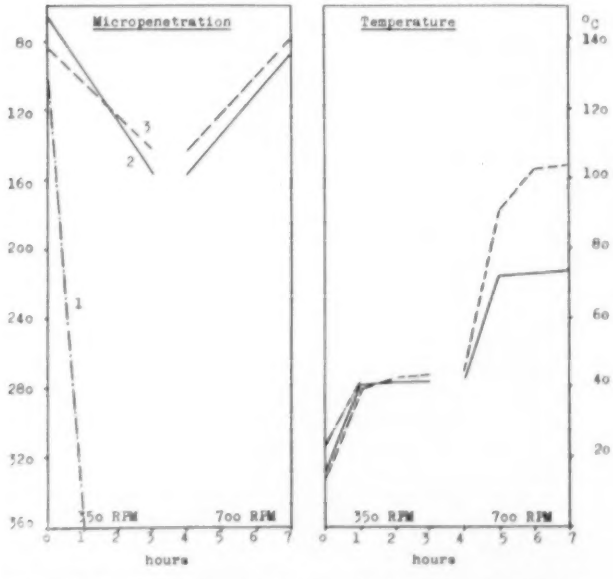


Figure 6. "Testing mixtures of two soap base components A and B"

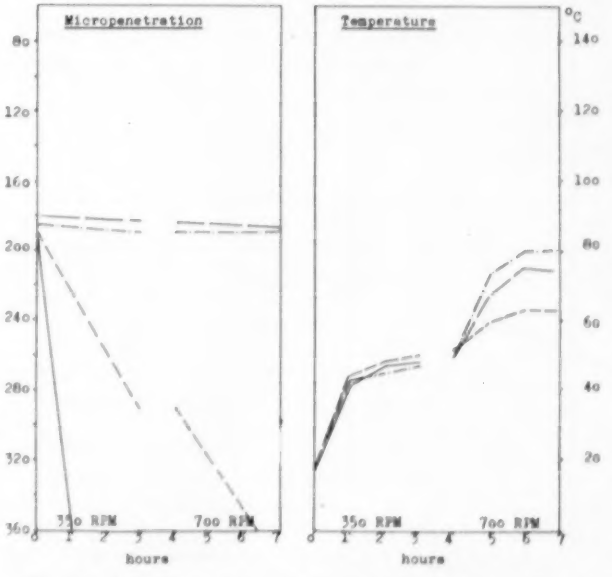


Figure 7. Shows how undetectable saponifiable changes can be solved

Grease No. 3 showed a continual decrease in consistency. The temperature in the apparatus was normal. The quality of this grease is only average, but it may be used in roller bearings.

Greases No. 4 and No. 5 represent really top quality roller bearing greases. Despite the severity of the test, the consistency has not changed. It was not affected by speed as was the case with grease No. 2. Experience has shown that this grease gives very good results in practice.

Other interesting results were obtained by testing mixtures of two soap base components (A and B), as shown in Figure 6. Three greases were manufactured by the same procedure, but with different ratios of A and B.

Grease No. 1 contained the saponifiable A and B components in the ratio of 6:4. Before the first measurement of consistency the grease became soft and leaked out.

Grease No. 2 was composed of equal parts A and B. This grease can be used for lubrication. The soap fibrils dominating grease No. 1 have been altered so that all disadvantageous qualities have disappeared.

Grease No. 3 was composed of A and B in the ratio 4:6. The results were more or less the same as for grease No. 2. The high temperature developed is rather unfavorable. This is another indication of a change of structure of the soap fibrils, compared with Greases No. 1 and 2.

It is well known by all manufacturers of lubricating greases that the variability of a lubricating grease is sometimes due to undetectable changes in the quality of the saponifiable materials. Figure 7 shows how a problem of this kind was solved in a short time. From time to time a sodium base grease controlled with the 3-ball tester gave quite variable results. After a few experiments it was found that the addition of another fatty acid gave excellent and constant test results with the 3-ball tester. The variation in quality of the grease referred to was eliminated by mixing the first fatty material with the new one in a ratio of 3:1.

Saponification of a Lubricating Grease

Although oils and saponifiable components affect the properties of a lubricating grease, saponification, temperature, and pressure condition and cooling effects are often more responsible for the resulting quality than the basic materials. The 3-ball tester is of much value in this special field of research.

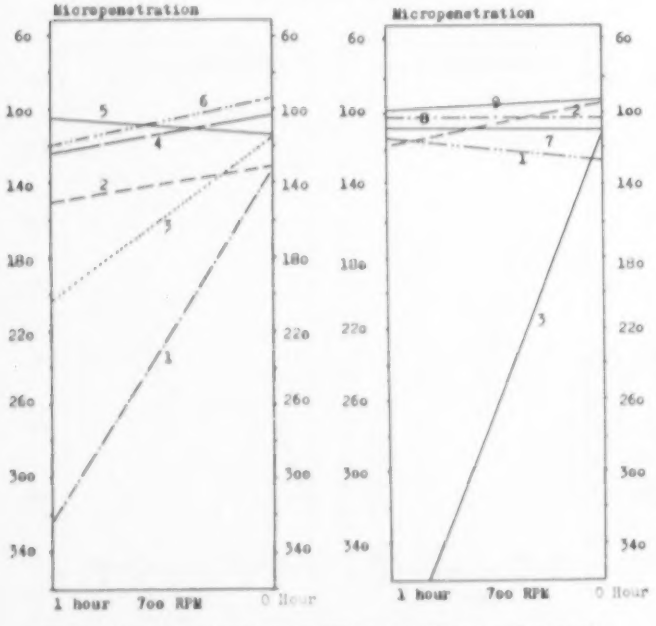
In the experiment illustrated by Figure 8 we were trying to find out how saponification time at the same temperature and end temperature of the batch affected the properties of a lithium base grease. Composition and cooling rates were the same in all experiments. The only difference between Greases 1 and 2 was a 50 times longer saponification time at 100°C with No. 2 than with No. 1. This prolonged saponification had a very harmful effect on the structure and the properties of the soap particles. After a short test time, Grease No. 2 became fluid. Grease No. 1, on the other hand, was in excellent condition.

Concerning the effect of end temperature of the batch, Grease No. 3 was brought to 180°C, Grease No. 4 to 200°C, and Grease No. 5 to 220°C. The results were quite different and without doubt were related to the solubility of the soap particles in the oil. The greases were also tested by chemical methods, but showed no differences, so that it was impossible to predict their different behaviors. With the 3-ball tester, an excellent picture was obtained within a few days.

The Compatibility of Different Greases

The 3-ball tester is an excellent piece of equipment for testing the compatibility of different greases. Results may be obtained after one hour of working at 700 rpm.

Figures 9, 10 show the behavior of different mixtures of lubricating greases. We see from Figure 9 that



Figures 9 and 10 show the behavior of different mixtures of lubricating greases

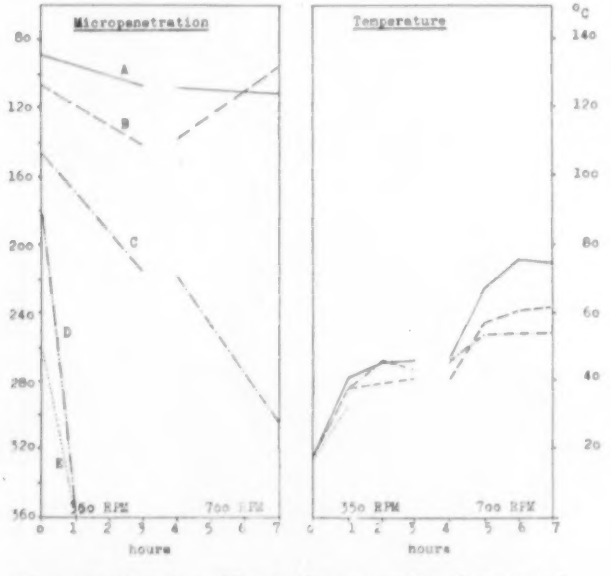


Figure 11 shows how different the test results of greases of the same alkali type base can be

5%of a sodium base grease caused complete breakdown of a Bentone grease, (No. 1). Better, but still bad, was the influence of 5% lithium soap grease on a Bentone grease, (No. 3). Fifty per cent of a sodium base grease, (No. 2) or lithium base grease, (No. 4) changed the behavior of a Bentone grease only slightly. Five per cent of a Bentone grease mixed with a sodium, (No. 5), or lithium base grease did not change the working resistance of the grease. In Figure 10, curves No. 7, 8, and 9 represent the components before mixing. Figure 12 shows the influence of lime base greases. Mixtures of 5% sodium with 95% lime base greases, (No. 1), and 95% sodium with 5% lime base greases, (No. 2), proved to be stable; 50:50 mixtures broke down immediately. In regard to the latter experiment we must remember that such mixtures have very low dropping points and that the work stability may be affected somewhat by the heat developed by the grease.

The Analysis of Competitive Lubricating Greases

How different the test results of greases of the same alkali type base can be, is shown in Figure 11. A, B, C, D, and E are measurements of lithium base greases available on the Swiss market. They show the whole spectrum of quality, from excellent to bad.

Conclusion

It was the intention of the present paper to describe a new method of grease testing and to show how and what results have been obtained with this tester. The results with the 3-ball tester are excellent, especially when compared with the expenditure in time and money required. But in spite of these good results and their conformity with practice, we should never forget that the best test method for lubricating greases, as well as for all materials, is practical use itself.

Patents and Developments

Telomer Greases

Some greases, such as those of the completely fluorinated hydrocarbon oil type, are valuable in that they are extremely resistant to corrosive conditions due to their chemical inertness. However, such oils have the disadvantage that their viscosity index is unsatisfactory.

In U. S. Patent 2,695,880 issued to E. I. DuPont de Nemours & Company, polyhalocarbon greases are claimed to be produced which are stabilized against changes in viscosity and plasticity over wide variations in temperature. This is achieved by mixing (1) 70%-90% by weight of a telomer oil consisting of telomers of monochlorotrifluoroethylene or intertelomers of this monomer with tetrafluoroethlyene with chloroform or carbon tetrachloride, with (2) 10%-30% of a telomer of tetrafluoroethylene with chloroform or carbon tetrachloride. The latter has a molecular weight range of 2500-4000. The improved oils and greases are prepared by mixing the first telomer (or intertelomer) into a suspension of the second telomer in an excess of telogen (chloroform or carbon tetrachloride), after which the latter is removed, perferably under vacuum at 20°-100° C. Trichlorofluoroethylene polymers may be produced as outlined in Industrial & Engineering Chemistry, 39, 29-354 (1947). The tetrafluoroethylene telomers may be produced in accordance with British Patent 583,874.

The preferred compositions are greases containing about 75% by weight of the chlorotrifluoroethylene chloroform telomer stabilized by after-treatment with a fluorinating agent such as CoF_3, AgF_2 or MnF_4, followed by fractional distillation to yield an oil having a boiling range of 100°-220° C. at 1 mm. Hg., and 25% of tetrafluoroethylene–carbon tetrachloride telomer having an average molecular weight of about 3000. The composition is a grease-like material which may vary considerably in consistency and appearance. Those based on chlorotrifluoroethylene telomers are smooth non-tacky translucent and opalescent greases of light straw to gray color.

One advantage of these greases is that various temperature and viscosity characteristics may be designed to fit any particular requirements with respect to consistency.

Lithium Hydroxy Carboxylic Acid Soap Greases

Lithium 12-hydroxystearate greases are ordinarily prepared commercially by heating a mixture of the soap and oil to above 400° F., which involves certain difficulties, equipment problems, and deleterious effect on oxidation stability. According to the Standard Oil Company (Indiana) patent 2,697,693, an improved low-temperature process may be used in obtaining high yields of semi-solid to solid lubricant greases comprising lithium 12-hydroxy stearate or lithium soap of hydrogenated castor oil, with uniformity maintained from one batch to another.

In a preferred procedure, a lubricant grease is prepared by charging a mixture of 12-hydroxy stearic acid, lithium hydroxide hydrate, water, and an oleaginous vehicle, preferably a solvent extracted mineral oil, to a jacketed pressure vessel having a stirring mechanism therein. After having charged the vessel with the above-named constituents, the vessel is sealed and the contents are heated by introducing steam to the vessel jacket under sufficient pressure to raise the temperature of the mix in the vessel to at least about 275° F. The water in the mixture is vaporized at such temperatures and develops a pressure within the vessel approximately equal to the pressure in the jacket. It is preferred to operate at a temperature in the range of from about 300° F. to about 330° F. which is obtainable with steam at a pressure of from about 50 to 95 psi. The mixture within the vessel is continuously agitated while it is being heated in this manner. When the temperature of the batch reaches

the desired point it is preferably held at such temperature for a relatively short time, e. g. from about 10 minutes to about an hour or longer, after which the steam is vented in order to relieve the pressure. The venting of steam may be begun the moment the temperature reaches the desired level but, as a practical matter, it is desirable to hold the batch at such temperature for a short period of time. It is critical, when venting the steam, that the temperature of the batch be held at substantially the same temperature to which it had been heated, i. e. there should be no more than about 10° drop in batch temperature during the removal of steam. Rapid agitation should be continued during the release of steam. The introduction of steam to the vessel jacket at somewhat higher pressure results in the heat necessary to drive off the steam without causing a drop in the temperature of the batch itself. When the steam is flashed from the vessel without regard to reduction in temperature of the batch, although a somewhat improved product is obtained as compared to merely heating the mixture to such a temperature at atmospheric pressure, a softer grease having much poorer consistency results. When the vessel is opened, after the pressure is relieved, the contents often appear lumpy and somewhat grainy but can readily be smoothed to the desired consistency by milling the same, e. g. in a colloid mill. The resulting grease is claimed to possess excellent mechanical and oxidation stability and low leakage characteristics.

By the term "yield" is meant the relationship between the amount of soap employed and the amount of oleaginous vehicle employed to produce a given quantity of grease of desired properties. Thus, the smaller the amount of soap employed to obtain a given quantity of grease of a particular consistency, the higher is said to be the "yield."

The yields of grease which are obtainable by this method are claimed to be a substantial improvement over those obtained by prior art methods employing temperatures below the melting point of lithium 12-hydroxy stearate or the lithium soap of hydrogenated castor oil. Thus, by this process, greases having excellent penetration values and fiber dispersement are said to be obtainable with soap contents as low as about 3 to about 15 per cent. When oil and such relatively low amounts of soap constituents are heated to the temperatures employed, in an open kettle (without pressure), a fluid slurry, rather than a grease, results. Higher percentages of soap, for example 15 to 30 per cent or even more, may be employed if desired. Greases prepared in accordance with the invention are claimed to have been found to be equivalent in every way, if not superior, to greases prepared by high temperature prior art methods.

In accordance with the invention, it is essential that the batch, before heating, constitute at least about 1 per cent of water by weight, preferably at least about 1½ per cent. Larger amounts of water may be employed, but more than about 5 per cent appears to be unnecessary since it does not contribute to any substantial improvement but must nevertheless be vented without reducing batch temperature which obviously would be a waste of heat. The continued presence of water in such an amount during the heating step contributes, in large measure, to achievement of the objects of the invention.

The following is an example of the preparation of a typical grease under the patent:

600 pounds of a mixture, comprising 89.6 per cent of a phenol extracted SAE 40 lubricating oil, 9.8 per cent 12-hydroxy stearic acid, 1.6 per cent lithium hydroxide monohydrate and .2 per cent of an amine type oxidation inhibitor marketed by DuPont under the designation PSF-34 or Ortholeum 300 (a mixture of substituted aromatic amines), was charged to the autoclave. To this mixture was added 30 pounds of water and the autoclave was sealed. By introducing high pressure steam to the jacket of the autoclave the mixture was then heated with agitation to 300° F. at which temperature an internal pressure of 75 pounds per square inch was developed. The batch was held at 330° F. for about 45 minutes after which the steam was vented rapidly with a substantial drop in batch temperature. A relatively soft grease having an unworked penetration at 77° of 337 and a worked penetration of 342 was obtained by milling a sample of the batch in a colloid mill. Electron photomicrographs of the sample indicate relatively poor dispersion of soap fibers and a poor L/D ratio.

The batch prepared as above, was reheated to a temperature of 330° F. in the autoclave after having added 25 pounds of water thereto. A pressure of 75 pounds per square inch was developed into the autoclave. The batch was held at such temperature for approximately 30 minutes. The pressure was then relieved by venting the steam while being careful to maintain the batch temperature at 330° F. by the introduction of additional amounts of high pressure steam to the jacket and stirring the mix at full speed. A heavier more fibrous product was obtained which upon removing a sample and milling it in a colloid mill gave a smooth grease having an unworked penetration of 276 and a worked penetration of 278. The dropping point of this grease was 390° F. + and electron photomicrographs indicated that the fibers were well dispersed with a good L/D ratio.

Greases Thickened with Acyl Ureas

Acyl derivatives of urea (e. g. octadecanoyl urea) are employed as thickening agents in U. S. Patent 2,698,300, issued to California Research Corporation. Because metal soaps are pro-oxidative, it has been necessary to incorporate large amounts of oxidation inhibitors in greases containing them. Acyl urea greases are claimed to be more resistant to oxidation and also to have increased melting points. They are also said to be more resistant to heat and not to lose their thickening action as readily.

One use for such greases is in systems which are not readily accessible and in sealed bearings and similar applications. The compositions comprise mainly oils of lubricating viscosity and acyl ureas or thioureas containing a total of 11-27 carbon atoms, preferably 12-18.

A typical grease according to this patent is prepared as follows:

A mixture of 10 grams of octadecanoyl urea and 30 grams of a California solvent-refined paraffin base lubricating oil having a viscosity of 185 SSU at 210° F. was heated with agitation to 300° F., then cooled to room temperature.

The resulting grease was fibrous, and had a melting point of 290° F.

PEOPLE in the Industry

NLGI Member From Across Pacific Describes Last Annual Meeting

Here Is His Description He Translated From Original Japanese

I had the pleasure of being invited to the 22nd Annual Meeting of the NLGI at the Mark Hopkins Hotel in San Francisco. Mr. Kageyama, chief of our laboratory, accompanied me during the three day's convention which opened October 25, 1954.

I take the liberty of presenting the program of the meeting, and giving my impressions of the progress of the conference, so that we may better understand the present situation of the grease industry, not only in America, but also in other countries.

The welcome speech by Mr. G. A. Olsen, President, commenced the meeting at 10 a.m. on October 25. In this speech, newly joined members of the year were introduced. The number of members has increased yearly, and approximately four hundred and fifty attended this year. Mr. Olsen extended a special welcome to Kyodo Yushi Co., Ltd., pointing out that we had traveled all the way across the Pacific to be present.

Mr. Jess W. Tapp, Vice Chairman, next gave a lecture on "Agricultural Market," which I considered remarkable, both in its content, and in the fact that it clearly illustrated the broadmindedness of the American people in relating political problems to the importance of the grease industry.

The study of the internal structure of grease was brilliantly discussed by a panel of eminent chemists, including such international authorities as I. E. Puddington, R. H. Leet, and M. J. Vold. After vivacious speeches made by the panel members, a general discussion was opened to audience participation.

The audience entered in with enthusiasm and the result was a well organized theoretical debate. Though it was a lengthy and intense session, no one showed fatigue, each being conscious of the fact that this meeting was his.

On the second day, the utility of grease was discussed. The audience reacted with keen interest to the enthusiastic way in which the panel took up the subject.

That afternoon several companies presented research publications of new-style grease plants.

I especially wish to state that all the lecturers, when introducing their new

日本の新會員と關係者えの挨拶

―一九五五年々頭に際して―

（米國グリース協會）
N・L・G・I會長　H・L・ヘミングウエイ

ナショナルグリース協会は一九三三年なわち、わずか二十二年前に設立されたでありますが、現在七〇社の正会員と六二社の賛助会員、一社の販売兼会員、六の技術会員を擁して居ります。正会員と協会全会員及協会全役員にかわり、新会員たる協同油脂株式会社、及び日本グリース業界の同業者各位、得意先各位、関連産業各位に対し、御挨拶申上げます。

そもそも当協会が北米大陸以外から協会員を迎えるようになつたのは、此処数年来のことで、現在ヨーロッパに弊社の会員を有して居り、北米大陸とヨーロッパ以外では、貴社が最初であります。

Hemmingway Sends Greetings to Japanese Member

Recently our NLGI President sent greetings to an Active Member. Here is his picture and part of his message in Japanese as it appeared in the Kyodo Grease Times, published by the Kyodo Yushi Co., Tokyo.

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style grease plants, distributed prints and pictures, or illustrated with slides in unsparing quantities, to better explain details of their equipment.

That night a social dinner party was held, at which time the President and Directors newly elected for the next term were introduced, followed by praises to those who had accomplished distinguished services.

On the 27th, the last day of the meeting, the technical committees submitted reports, after which questions and answers were freely invited.

The audience eagerly posed questions, one after another, and I observed that the brisk speeches that they made kept the men attending the microphones fully occupied.

I have just related briefly the progress of the meeting, adding my impressions. However, I wish to repeat again that I was struck with admiration by the earnest debate, deliberate technique, and frank speeches, and I seriously realized the importance of the future of the Japanese Grease Industry.

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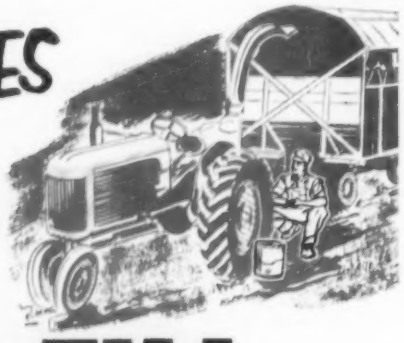

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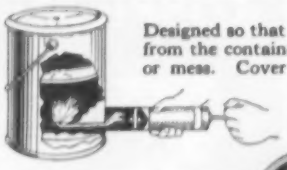

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President's Page Attracts Attention

Considerable interest has centered on our President's page this year, as evidenced by this letter to NLGI President Hemmingway from the Executive Secretary of IOCA. This is what he had to tell our president regarding his February editorial:

Dear Hugh:

I read with much interest your editorial on the President's page of the February NLGI Spokesman.

Since I was a charter member of NLGI I know that the facts regarding the work of the Technical Committee of the Institute are exactly as you have outlined them. However, you may not recall that at the time of the organization of NLGI the ASTM particularly was a little suspicious that the work of the Technical Committee would encroach upon their activities.

As matters worked out, in the way you have clearly outlined them, I am sure that Committee D-2 of ASTM is mighty grateful for the preliminary work which was done on various methods and then turned over to them so that tentative standards and standard methods could be developed.

Of course, in the early days the most important work which was done was the development of the NLGI classification of lubricating grease. It was and has been a boon to all manufacturers and also users.

Sincerely,

RALPH E. MATTHEWS

Executive Secretary, Independent Oil Compounders Assn.

Peters Elected Board Chairman of Oil Kraft

Mr. Guy Peters, formerly President of Oil-Kraft, Inc., Cincinnati, Ohio, manufacturer of lubricating greases, oils and soaps has been elected Chairman of the Board of Directors of the Company at its annual meeting held in January.

The Board elected as President Mr. John R. Bunnell who was one of the founders of the Company when it was organized in 1925. Other officers elected were Mr. Robert L. Peters, Vice President and Treasurer and Mr. Matthew J. Kabbes, Secretary and General Manager.

Oil-Kraft, celebrating its thirtieth anniversary in 1955, is one of the few independent grease manufacturers in the United States. It recently erected new warehouse and manufacturing facilities, more than doubling its former factory.

Heyden Chemical Appoints Whitfield

Jacques J. Whitfield has been named manager of the newly formed Stearates Division of Nuodex Products Co., Inc., a subsidiary of Heyden Chemical Corporation, it was announced by T. M. O'Neil, Nuodex vice-president for marketing.

In this capacity, Whitfield will be responsible for the sale and market development of the new line of stearates manufactured in Nuodex' Newark, N. J. plant. Standard and specialty grades of stearates will be available to meet the needs of manufacturers of surface coatings, printing inks, pharmaceuticals, cosmetics, greases, paper, building materials, rubber, plastics, metal molding powder, etc.

For sixteen years prior to joining Nuodex, Whitfield was Stearate Sales Manager of Sun Chemical Corporation. He lives with his wife, Ruth, at 65-24 Cromwell Crescent, Forest Hills, Long Island, New York.

Robert Wilkerson to Minerals & Chemicals

Minerals & Chemicals Corporation of America has announced the appointment of Robert W. Wilkerson to the newly created position of Advertising and Sales Promotion Manager with headquarters at the home office in Metuchen, New Jersey.

Mr. A. G. Blake, Executive Vice President, said that with the expansion of products and markets as the result of the merger of Edgar Brothers Company and Attapulgus Minerals & Chemicals into Minerals & Chemicals Corporation of America, there arose a need for the coordination of the advertising and sales promotion activities of all the various divisions of the new corporation.

Mr. Wilkerson was formerly an account executive and secretary of Kenyon-Baker Co., Inc. advertising agency in Newark.

Dr. Douglas Calder Joins Mallinckrodt

The Board of Directors of Mallinckrodt Chemical Works Limited, Montreal, has named Dr. Douglas S. Calder vice-president and general manager. He has also been elected to the board of directors.

Dr. Calder was previously with Dominion Tar & Chemical Company, Ltd., as assistant to the vice-president responsible for special assignments and investigations into operations at large. Before this he was vice-president in charge of operations with Standard Chemical Company, Ltd., Toronto. During the past several years Calder has directed his attention in the Canadian chemical industry to administrative duties and research and development.

Dr. Calder will take over active management of Mallinckrodt about June 1. Since July 1954, Mr. Dudley Batchelor from Mallinckrodt Chemical Works, St. Louis, has been acting manager of the Canadian company. He will return to a new position in the St. Louis office when Dr. Calder assumes his new duties.

★

Forty-two separate steps are required for the proper lubrication of front wheel bearings according to the National Lubricating Grease Institute, Kansas City, Missouri.

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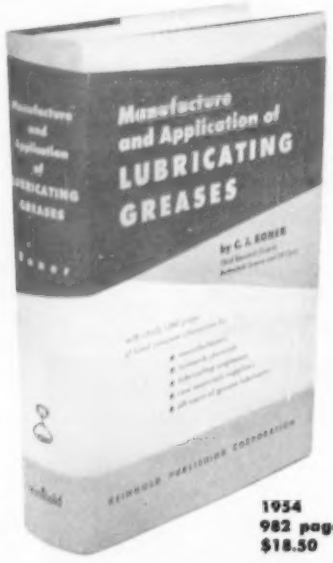
Manufacture and Application of LUBRICATING GREASES

by C. J. Boner

Chief Research Chemist
Battenfeld Grease and Oil Corp.



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Here in one giant volume . . . the most complete storehouse of information ever published on the composition, properties and uses of lubricating greases!

The book begins by describing in detail the structure and theory of lubricating greases. Then follow chapters on the various raw materials, processes and manufacturing equipment. Lubricants containing specific thickeners, including such recent developments as lithium soaps, complex soaps and non-soap gelling agents, receive special attention.

Of major interest is the large section on present uses and future trends of lubricating grease products. Here you'll find the complete details of when, where, and how to apply a specific lubricant for any given purpose.

Everyone concerned with the preparation or use of grease lubricants will find Boner's book of enormous practical value. Manufacturers and lubricating engineers will find here a complete breakdown of the effects of each ingredient or treatment upon the characteristics of the final product, and a full explanation of the physical and chemical methods used in measuring these characteristics. Suppliers of fats, oils, additives, thickeners and other raw materials will gain new ideas for future product research and development. In addition, users of grease products will learn the properties of available lubricants and the major purposes that each fulfills.

982
FACT-FILLED PAGES
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23
BIG CHAPTERS

1 Introduction
2 Structure and Theory
3 Additives Other Than Structural Modifiers
4 Raw Materials
5 Manufacturing Processes
6 Equipment for Lubricating Grease Manufacture
7 Aluminum Base Lubricating Greases
8 Barium Base Lubricating Greases
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19 Residua and Petrolatums as Lubricants
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21 Tests of Lubricating Greases and Their Significance
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Industry NEWS

Acheson Colloids Announces Bulletin

A revised four-page Bulletin, No. 421, containing photographs, diagrams, charts, and information, on the advantages offered by colloidal graphite in the assembly and run-in of machines, has been released by Acheson Colloids Company. This bulletin shows how to use colloidal graphite, chiefly in the form of a petroleum oil dispersion.

Copies of Bulletin No. 421, "'dag' Colloidal Graphite for Assembly and Run-in of Engines and Machinery," are available by writing Acheson Colloids Company, Division of Acheson Industries, Inc., Port Huron, Mich.

Witco Chemical Company Acquires Emulsol Corporation

Announcement is made that Witco Chemical Company, of 260 Madison Avenue, New York, N. Y. has acquired the Chemical Division of The Emulsol Corporation, of Chicago, Ill., and has organized Emulsol Chemical Corporation to manufacture the many chemicals which have been produced in these facilities for many years.

Continuing as president of Emulsol is Benjamin R. Harris, identified with the company since its inception. Solomon Epstein, connected with the company for many years, will serve as Executive Vice President.

Key personnel of the Emulsol Chemical Corporation have been prominently identified, during the past 30 years, with major developments in surface active agents for wetting, emulsifying, dispersing, foaming, sanitizing, bodying, deflocculating, defoaming, and cleansing for use in many processing industries such as food, pharmaceuticals, cosmetics, paper, rubber, leather, textile, ore beneficiation, cleaning, laundering, protective coatings, lubricants and pesticides.

Swan-Finch to Increase Capitalization

Stockholders of Swan-Finch Oil Corporation voted at a special meeting on Tuesday, January 25, to increase the authorized number of shares of the 101-year old company's common stock from 160,000 shares to 1,000,000 shares, it has been announced by Robert F. Six, Chairman of the board of directors. Six said there were no plans for issuing the additional stock immediately, but that it would be available for use in future expansion.

U. S. Steel Hour Honored

The United States Steel Hour and its director, Alex Segal, have been jointly honored by *Modern Photography* magazine for outstanding TV photography. Presentation of a plaque, The Award of Excellence, was made to Segal by U. S. Steel's George Hicks on behalf of the magazine, during a recent Steel Hour telecast.

Mallinckrodt Appoints Carr and Brinner

St. Louis, Mo., March 4, 1955—The Board of Directors of Mallinckrodt Chemical Works, St. Louis, today announced the appointment of Mr. Francis J. Carr as Vice-President and Mr. Harold A. Brinner as Controller.

Mr. Carr joined Mallinckrodt in 1946 as Controller. Previously he was Controller of American Air Lines and the Tennessee Valley Authority. He was also Vice-President of Finance, American Steel and Wire Division of United States Steel, and was an organizer and first President of the Controllers Institute of America.

Mr. Brinner, before joining Mallinckrodt in 1954 as Assistant Controller, had been since 1938 associated with Price Waterhouse & Company. He is a graduate of Washington University in St. Louis.

★

The $8 billion invested and plowed back into the oil industry in the past five years has increased production and reserves by one barrel for every four produced in 1945.

REPUBLIC STEEL PAILS AND DRUMS for Oils, Greases, etc.

No. 9 pail with lug cover and choice of pour spouts for 5 gallons oil or 35 to 40 pounds grease.

REPUBLIC STEEL PAILS

Fabricated from black steel—outside painted or lithographed to order. Removable tops with lug covers, with or without pour spouts.

100 lb. or 120 lb. grease drum with 14 inch full open-top 20 lug cover. Offset bottom for stacking.

REPUBLIC OIL DRUMS

55, 30 and 15 gallon capacities. Full open head or bung type. Painted or fully decorated. Interior lacquered if desired.

All made to new Petroleum Industry Specifications.

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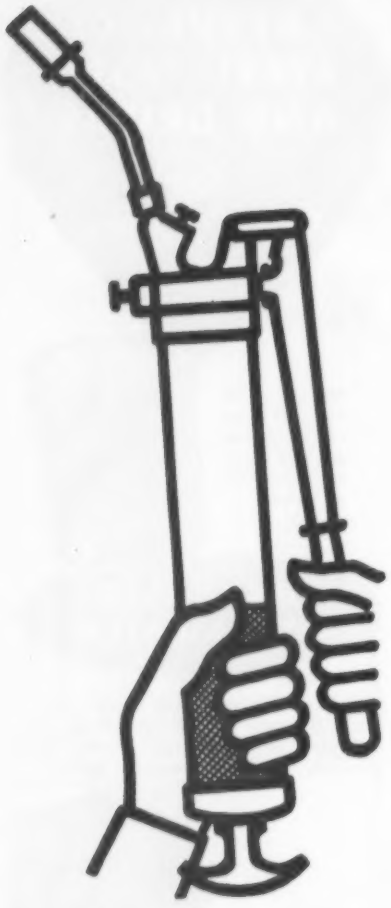
PRESSED STEEL DIVISION
465 WALNUT STREET • NILES, OHIO
General Offices • Cleveland 1, Ohio
Export Dept. Chrysler Bldg. New York 17, N. Y.



for every lubricating job

PENOLA AUTOMOTIVE LUBRICANTS

GREASES, CUTTING OILS

are available to meet your most exacting lubricating jobs, laboratory tested and quality-controlled for your protection.

Penola

PENOLA OIL COMPANY
15 West 51st Street, New York 19, N. Y.

Directory of Commercial and College Testing Laboratories

This Directory is a successor to the *Directory of Commercial and College Laboratories* published in 1947 by the U. S. Department of Commerce, National Bureau of Standards, as Miscellaneous Publication M 187. Responsibility for its compilation and publication has been transferred from the National Bureau of Standards to the American Society for Testing Materials by agreement between the two organizations.

The Directory lists the locations of testing laboratories equipped and prepared to undertake testing on a commercial or fee basis. Information is given concerning 278 commercial testing laboratories and their 151 branches or offices. There is also presented a list of the laboratories of 86 colleges that are prepared to do testing under certain conditions. Research and consulting laboratories are not listed unless they also are engaged in testing on a commercial basis.

The Directory is designed to be of assistance to purchasers not equipped to make their own tests, and who therefore have hesitated to buy on specifications. The knowledge that they can at any time call on testing laboratories to check deliveries made to them on specifications should induce many purchasers to take full advantage of the specification method of buying. It will also be of value to small manufacturers and others seeking testing laboratory services.

Although the Directory has been compiled from the viewpoint of the testing of commodities, the classification includes a few items not strictly commodities, but which are becoming increasingly important in the fields of manufacturing, construction, and sanitation; e.g., air (pollution), industrial water and wastes, and building constructions.

Using a code system of letters and numbers, a maximum of information is given in a minimum of space. The Directory will give the user a good indication of the laboratories most likely to be prepared to undertake the tests desired. It does not pinpoint every possible test within the many laboratories, but when used as the guide it is intended to be the user can readily select the nearby laboratories which will most likely be able to fulfill his testing needs.

Copies may be purchased from the American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa. Price $1.00.

API Publishes New Manual

Ways and means for service station operators to improve their business management techniques are blueprinted in detail in a new manual published by the Division of Marketing of the American Petroleum Institute.

The new manual, which is entitled "Service Station Management: Converting Service to Profit," discusses virtually all phases of successful service station development. In addition, it also contains a series of aids and references for further study.

Among specific subjects covered are these: how to keep customers loyal; how to get new customers; how to meet competition; how to increase profits; how to recruit and train employees; how to control stock; how to extend credit; how to keep records; how to develop good public and employee relations.

The manual was prepared by the Marketing Division's Personnel Training Committee, which is made up of top marketing executives of integrated companies, jobbers with outstanding reputations in training their service station employees, and eminently successful men engaged in retailing petroleum products. Copies may be obtained at 50 cents each from Division of Marketing, American Petroleum Institute, 50 West 50th Street, New York 20, N. Y. Discounts are provided for bulk orders.

Significantly, the manual makes this observation:

"The day is past, if it ever was, when just anybody could operate a service station successfully. Service station operation is now a specialized business. It demands technical knowledge and skill, sound business practices, and competent management."

★

"Always throw used cotter pins away," says the National Lubricating Grease Institute, Kansas City, Missouri, in their new manual "Recommended Practices for Lubricating Automotive Front Wheel Bearings."

New Bulletin Describes Colloidal Graphite

An entirely new publication, Bulletin No. 433, containing information, photographs, and charts pertaining to colloidal graphite applications in the electronic and electrical industries, has just been published by Acheson Colloids Company, Port Huron, Michigan.

This bulletin describes how "dag" Colloidal Graphite, a high-purity electric-furnace graphite processed to colloidal size and dispersed in a wide variety of fluid carriers, is used for coating the insides of cathode-ray tubes in order to prevent stray electrons from reflecting back into the electron beam. Also mentioned is the utilization of graphite films for increasing thermal radiation and for decreasing secondary emission, "back" omission and undesirable photo-electric effects in vacuum tubes. Methods for improving the efficiency of copper oxide rectifiers, improving connections between graphite coatings and ground wires, and attaching filaments to lead-in wires of various types of carbon filament lamps by means of colloidal graphite dispersions, are presented in the new bulletin.

In addition, procedures are given for electrostatic shielding of vacuum tubes, television cabinets, hearing-aid cases, and tape recorder cases. Static elimination in drive belts, dust collector bags, instrument windows, and airplane surfaces is described and lubrication of electrical devices which must operate for long periods of unattended service is explained. Numerous other electronic and electrical applications are also cited in the bulletin.

Copies of Bulletin No. 433, "'dag' Colloidal Graphite for Electronic and Electrical Applications" may be obtained from Acheson Colloids Company, Division of Acheson Industries, Inc., Port Huron, Mich.

Monsanto Book On Santolene C

Santolene C, Monsanto Chemical Company's "single treatment" rust and corrosion inhibitor for petroleum products, is the subject of a booklet just published by the company's Organic Chemicals Division.

An ashless organic liquid, the material prevents rust and corrosion problems in clean petroleum products at concentrations of from 10 to 40 parts per million, depending on the corrosiveness of the product. It is compatible with the antioxidants, scavengers, dyes and other additives used in gasolines.

Its use in tankers, pipelines, storage tanks and other petroleum handling facilities has resulted in considerable reductions of equipment and maintenance costs, according to figures cited in the booklet.

Because Santolene C is completely soluble in petroleum products it can be blended by injection or simple mixing, and its protection carries over to distribution equipment beyond the pipeline terminal. It controls corrosion by forming a barrier film on vulnerable metal surfaces.

Detailed case histories of Santolene C's performance in pipelines (one-third of those in the U. S.) and in oil tankers, are contained in the booklet, as well as data showing the effects of various dosages of Santolene C on aviation fuels, gasoline, distillate fuels, kerosene and other petroleum products. The booklet is available on request.

Produces more uniform product at lower cost

● Check these advantages gained by Shell Oil Company in its continuous processing of lithium hydroxystearate grease with VOTATOR® Grease Making Apparatus:

Higher production rate,
Lower labor costs.
Lower soap costs.
Eliminates fire hazard.
Makes consistency uniform.
Saves floor space.

Find out how *you* can benefit with Votator Grease Making Apparatus. Write The Girdler Company, Votator Division, Louisville 1, Kentucky.

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The GIRDLER Company
A DIVISION OF NATIONAL CYLINDER GAS COMPANY
VOTATOR DIVISION

Nopco Opens In Portland, Oregon

The Nopco Chemical Company has acquired new warehouse and office facilities in Portland, Oregon, and will henceforth be represented in that city by John J. Ryan, its Industrial Sales Representative for the Northwest.

According to Pere S. Brown, the Vice President of Nopco in charge of its Pacific Division, the new warehouse facilities at 1235 Northwest 12th Avenue are centrally located to all the important markets in the Northwest. He said that Nopco will maintain an office at the warehouse which will be the headquarters of Mr. Ryan when he is in town.

Nopco's Northwest representative since 1951, Mr. Ryan worked as a chemist for the company before switching to sales, and he has a technical as well as practical knowledge of the products he represents. These products include industrial chemicals for dozens of industries, among them textiles, tanning, paint, cosmetics, and plastics.

Frisch Advances At Houghton

Announcement is made by E. F. Houghton & Co., Philadelphia, of the appointment of Dr. Kurt C. Frisch as Assistant Manager of Research. Dr. Frisch was graduated from the University of Brussels in Belgium and awarded his Ph. D. Degree in Organic Chemistry at Columbia University. He has been Supervisor of Organic Research in the Houghton Laboratories since 1952.

He will be succeeded in that position by Dr. Ellis Abrams who was educated at the University of Pittsburgh and was formerly Supervisor of Textile Research for the Quaker Chemical products Corporation.

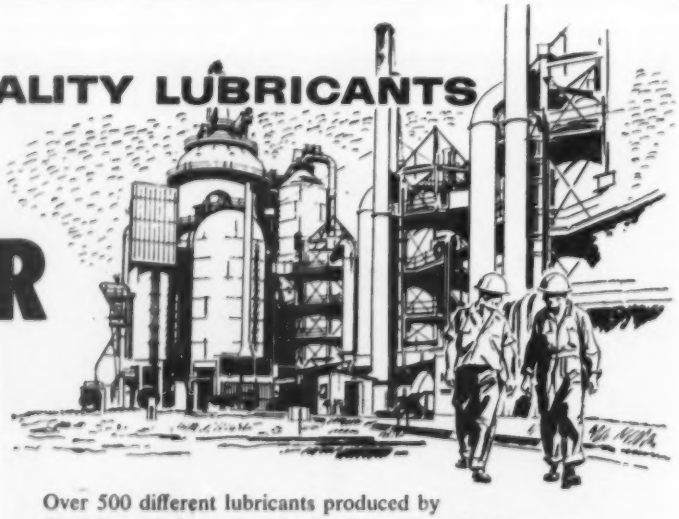
Socony-Vacuum's Salman Succeeds Hanson

Appointment of Phillips C. Salman as comptroller, effective April 1, was announced recently by Socony-Vacuum Oil Company, Inc. He succeeds Louis E. Hanson, who has been comptroller since 1946.

Mr. Salman was graduated from the School of Commerce and Finance, and attended the School of Law, of Northeastern University in Boston. He joined a predecessor company of Socony-Vacuum in 1919, in East Cambridge, Mass. He transferred to the company's New York headquarters in 1933 as assistant general credit manager. He was made general auditor in 1942 and assistant comptroller in 1945. He is general chairman of the Financial and Accounting Committee of the American Petroleum Institute and served as chairman of the A.P.I. subcommittee which issued an outline of petroleum industry accounting in 1954. He is a member of the Controller's Institute of America and a former director and vice president of the Institute of Internal Auditors. The new comptroller now lives in Bronxville, N. Y.

Mr. Hanson, at his own request, will go on leave of absence at the end of this month prior to retirement under Socony-Vacuum's annuity plan. He is a C.P.A. and a member of the American Institute of Accountants and the Controller's Institute of America.

OVER 500 QUALITY LUBRICANTS ARE PRODUCED BY SINCLAIR



For . . .

- TURBINES
- STEAM ENGINES
- DIESEL ENGINES
- METAL WORKING
- PLANT MACHINERY
- CONSTRUCTION EQUIPMENT
- AUTOMOTIVE EQUIPMENT

and many other applications

Over 500 different lubricants produced by Sinclair are helping the wheels of American Industry turn faster – easier and more efficiently. Each one of these top-quality lubricants is *specifically* designed for a *specific* need . . . each is a product that can be used with confidence.

No matter what your lubrication problem may be . . . a letter to Sinclair may bring you a solution.

SINCLAIR REFINING COMPANY

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FUTURE MEETINGS of the Industry

APRIL, 1955

13-15 American Inst. of Electrical Engineers (Southern District meeting No. 4), St. Petersburg, Fla.

13-15 American Society of Lubrication Engineers (annual meeting), Sherman Hotel, Chicago, Ill.

13-15 National Petroleum Association (52nd semiannual meeting), Cleveland Hotel, Cleveland, Ohio

18-19 Oil Industry TBA Group (aeronautic meeting), St. Charles Hotel, New Orleans, La.

18-20 American Society of Mechanical Engineers (Spring meeting), Lord Baltimore Hotel, Baltimore, Md.

18-21 Society of Automotive Engineers (aeronautic meeting), Hotels Statler and McAlpin, New York, N. Y.

19-20 Michigan Petroleum Association (annual meeting), Hotel Leland, Detroit, Mich.

20-22 Petroleum Industry Electrical Association (annual conference), Shamrock Hotel, Houston, Tex.

25 American Petroleum Institute (OIIC Steering Committee meeting), Conrad Hilton Hotel, Chicago, Ill.

25-26 Independent Petroleum Assn. of America (midyear meeting), Plaza Hotel, San Antonio, Tex.

26-27 Southern California Oil Industry (regional safety conference), Pacific Coast Club, Long Beach, Calif.

28-29 American Petroleum Institute (Division of Production, Pacific Coast District Spring meeting), Statler Hotel, Los Angeles, Calif.

MAY, 1955

1-4 American Institute of Chemical Engineers, Shamrock Hotel, Houston, Tex.

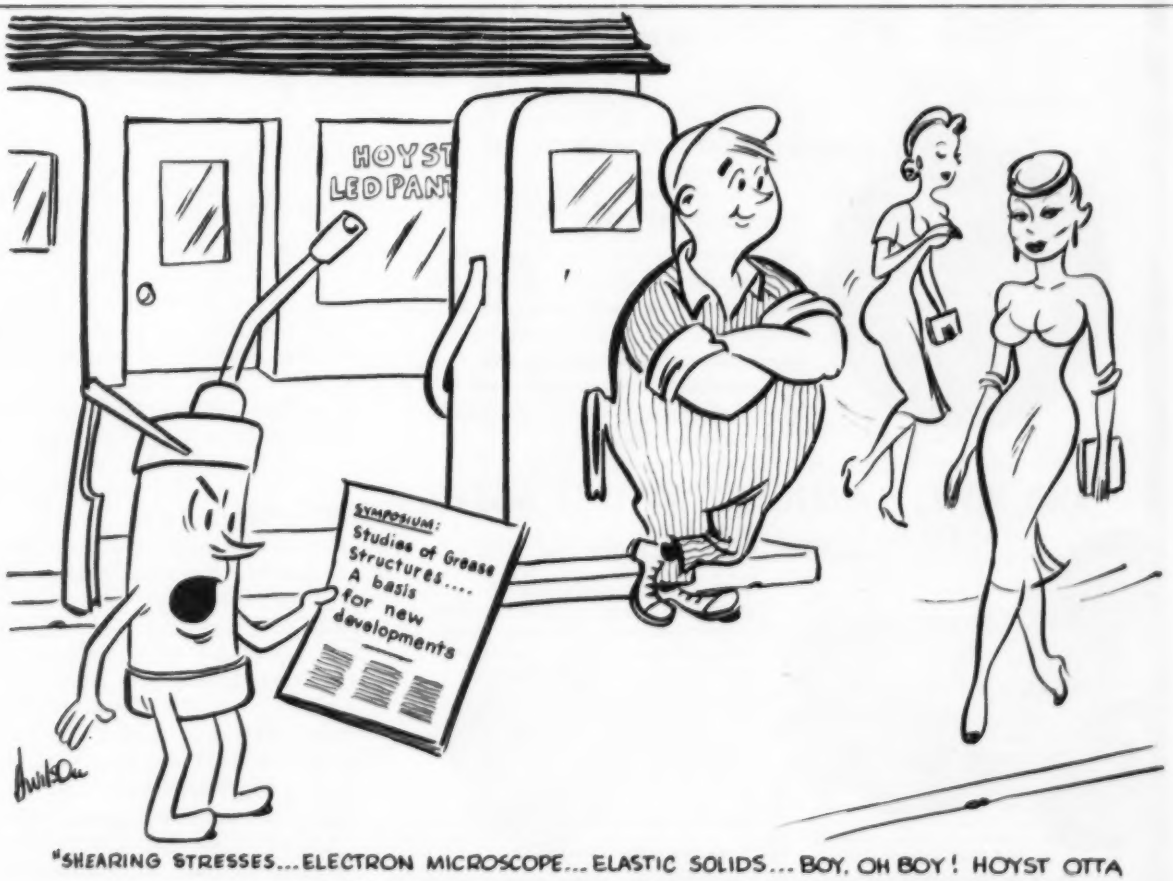
2-4 United States Chamber of Commerce (annual meeting), Washington, D. C.

2-4 American Petroleum Institute (Evaporation Loss Committee and Subcommittee meetings), Edgewater Beach Hotel, Chicago, Ill.

4-6 American Inst. of Electrical Engineers (Middle Eastern District meeting No. 2), Deshler-Hilton Hotel, Columbus, Ohio

8-10 Empire State Petroleum Assn. (annual convention and trade exhibit), Biltmore Hotel, New York, N. Y.

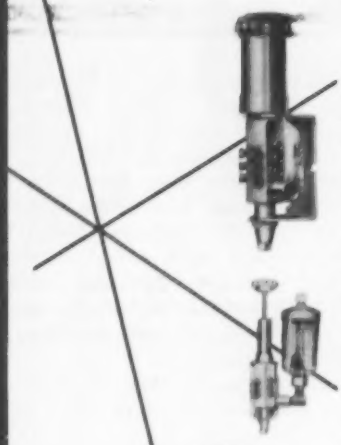
9-12 American Petroleum Institute (Division of Refining midyear meeting), Jefferson Hotel, St. Louis, Mo.



"SHEARING STRESSES... ELECTRON MICROSCOPE... ELASTIC SOLIDS... BOY, OH BOY! HOYST OTTA GET A LOAD O' THIS! HE THINKS LUBE GREASES ARE MADE OF **JELLY!**"

Lincoln ENGINEERING COMPANY
announces
THE *Multi-Luber** SYSTEMS
FOR **POWER LUBRICATION**

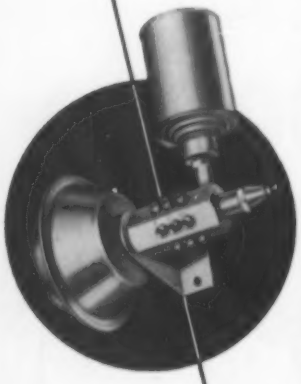
Applications Unlimited . . .



AIR-OPERATED

Adopted by leading Fleet and Bus Operators for automatic, controlled lubricant application each time driver applies the air brake. Complete Systems available in handy kits for simple installation. Air-Operated Multi-Luber Systems may be used wherever compressed air is available to reduce operating costs and increase efficiency on equipment ranging from transport trailers to automated, high speed lathes.

Where compressed air is not available, the air cylinder of the Multi-Luber can be replaced with a push button. These Manual Systems are available in kits for quick installation on tractors, farm implements, and a wide range of industrial machinery.



VACUUM-OPERATED

Multi-Luber Systems are also available for instantaneous, automatic lubrication of equipment ranging from light trucks to fork lift trucks, or for any application where vacuum is available. A touch of the control button, located wherever desired, delivers a pre-measured quantity of refinery-pure lubricant.

AND NOW . . . AVAILABLE ON 1955 model LINCOLN and MERCURY motor cars

Here is the newest and most revolutionary application of Lincoln's vacuum-operated Multi-Luber System. Now, purchasers of new Lincoln or Mercury motor cars have available instantaneous Power Lubrication at their own convenience. A mere touch of a button on the instrument panel provides the continuous pleasure of smoother car performance, greater steering ease and increased operating economy.

*Trade Name Registered Patent Pending

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PIONEER BUILDERS OF LUBRICATING EQUIPMENT FOR A QUARTER CENTURY

11-13 American Petroleum Institute (Division of Production, Eastern District Spring meeting), Wm. Penn Hotel, Pittsburgh, Pa.

14-22 World Wide Chemical Plant and Equipment Exposition and Congress, Frankfurt, Germany

15-17 Pennsylvania Petroleum Association (Spring convention), Bedford Springs Hotel, Bedford, Pa.

15-20 National Tank Truck Carriers, Inc. (annual convention), Mark Hopkins Hotel, San Francisco, Calif.

16-18 American Petroleum Institute (Division of Marketing, Lubrication Committee), The Greenbrier, White Sulphur Springs, W. Va.

16-18 American Petroleum Institute (Division of Transportation, Products Pipe Line Conference), Edgewater Beach Hotel, Chicago, Ill.

16-20 National Fire Protection Assn., Netherlands Plaza Hotel, Cincinnati, Ohio

19-20 National Industrial Conference Board, Waldorf-Astoria Hotel, New York, N. Y.

23-25 American Petroleum Institute (Division of Marketing mid-year meeting), Chase & Park Plaza Hotels, St. Louis, Mo.

26-27 AIME (Rocky Mt. Petroleum Sections joint meeting), Shirley Savoy Hotel, Denver, Colo.

26-27 Kentucky Oil & Gas Assn. (annual meeting), Lafayette Hotel, Lexington, Ky.

30 to June 1 Chemical Institute of Canada (38th annual conference and exhibition), Quebec City, Can.

JUNE, 1955

1-2 San Francisco Bay Area Industry Conference, Claremont Hotel, Berkeley, Calif.

6-10 American Petroleum Institute (Division of Production mid-year committee conference), Brown Palace Hotel, Denver, Colo.

6-15 Fourth World Petroleum Congress, Rome, Italy

7-8 Petroleum Packaging Committee of the Packaging Institute, Broadview Hotel, Wichita, Kansas

7-9 National Oil Scouts & Landmen's Assn. (32nd annual convention), Banff Springs Hotel, Banff, Canada

8-9 American Petroleum Institute (OIIC meeting), Wm. Penn Hotel, Pittsburgh, Pa.

9-10 Pennsylvania Grade Crude Oil Association (annual meeting), Wm. Penn Hotel, Pittsburgh, Pa.

11-15 Petroleum Equipment Suppliers Assn. (annual meeting), Banff Springs Hotel, Banff, Canada

12-15 American Society of Agricultural Engrs. Illini Union (annual meeting), University of Illinois, Urbana, Ill.

12-17 SAE Golden Anniversary (Summer meeting), Chalfonte Haddon Hall, Atlantic City, N. J.

19-21 Northwest Petroleum Association (Summer conference), Point Lodge, Pequot Lakes, Minn.

20-23 American Society of Mechanical Engineers (semiannual meeting), Statler Hotel, Boston, Mass.

26 to July 1 ASTM Committee D-2, Petroleum Products and Lubricants, Chalfonte Haddon Hall, Atlantic City, N. J.

27 to July 1 American Institute of Electrical Engineers (Summer Meeting), New Ocean House, Swampscott, Mass.

JULY, 1955

19-21 American Petroleum Institute (Committee on Agriculture annual business meeting and field trip), Oregon State College, Corvallis, Ore.

AUGUST, 1955

15 American Petroleum Institute (OIIC Steering Committee meeting), Traymore Hotel, Atlantic City, N. J.

15-17 Society of Automotive Engineers (West Coast meeting), Hotel Multnomah, Portland, Ore.

15-19 American Institute of Electrical Engineers (Pacific general meeting), Butte, Mont.

21-26 National Congress of Petroleum Retailers, Inc. (9th Annual Session), Sheraton-Cadillac Hotel, Detroit, Mich.

FOR IMMEDIATE SHIPMENT...

Forerunners of New "A-D-Miracles" in Fatty Alcohol Development . . .

ADOL 54, predominantly cetyl, is a white, amorphous solid at room temperature, bland and dry. Supplied in N.F. quality if desired. Excellent for absorption bases, lotions, creams, pharmaceuticals and softeners.

ADOL 64, stearyl alcohol of exceptional quality. Used in making lube oil viscosity index improvers, pour point depressants, detergents, color dispersants, finishing agents and defoamers. Can be supplied in U.S.P. quality if desired.

ADOL 33, light colored liquid fatty alcohol, a superior low-cloud product for applications such as surface active agents, germicides, insecticides, shampoos, anti-static agents, softeners, lubricating oils, and many other applications where low cold test is important.

ADOL 65, a commercial grade of mixed cetyl and stearyl alcohol is also available for industrial applications.

These and numerous standard ADOLS, immediately available for shipment in car lots or tank cars from eight strategically located warehouses, are forerunners of advanced alcohols under development for manufacture at ADM, Ashtabula, Ohio.

You can keep abreast of what's coming by asking to have your name added to ADM's select list currently receiving advanced technical information on ADOLS and UNADOLS.

Hydrofol PRODUCTS

Hydrogenated and Distilled Fatty Acids and Stearic Acid . . . Hydrogenated Vegetable, Fish, Sperm Oil and Tallow . . . Hydrogenated Castor Oil . . . Stearyl, Cetyl, Oleyl, Alcohol . . . Sperm Oils and Spermaceti . . . Behenic Acid . . . Erucic Acid . . . Hydroxystearic Acid.

ARCHER • DANIELS • MIDLAND COMPANY

Chemical Products Division • 2191 West 110th St. • Cleveland 2, Ohio

30-31 Petroleum Packaging Committee of the Packaging Institute, Royal York and King Edward Hotels, Toronto, Canada

SEPTEMBER, 1955

8-9 American Petroleum Institute (OIIC meeting), Conrad Hilton Hotel, Chicago, Ill.

12-15 Society of Automotive Engineers (tractor meeting), Hotel Schroeder, Milwaukee, Wis.

14-16 National Petroleum Association (53rd annual meeting), Traymore Hotel, Atlantic City, N. J.

22-23 Mid-Continent Oil & Gas Assn. (La.-Ark. Division annual membership meeting), Roosevelt Hotel, New Orleans, La.

26-27 Independent Oil Compounders Assn. (annual meeting), Hotel Bismarck, Chicago, Ill.

25-28 American Institute of Chemical Engineers, Lake Placid Club, Lake Placid, N. Y.

OCTOBER, 1955

2-5 AIME Petroleum Branch (Fall meeting), Roosevelt Hotel, New Orleans, La.

2-6 ASTM Committee D-2, Petroleum Products and Lubricants, Statler Hotel, Washington, D. C.

3-7 American Institute of Electrical Engineers (Fall general meeting), Morrison Hotel, Chicago, Ill.

9-15 American Petroleum Institute Oil Progress Week

11-15 Society of Automotive Engineers, Hotel Statler, Los Angeles, Calif.

12-13 South Dakota Independent Oil Men's Assn., Mitchell, S. D.

18-22 National Safety Council (43rd National Safety Congress and Exposition), Chicago, Ill.

24-26 American Standards Assn. (annual meeting), Sheraton Park Hotel, Washington, D. C.

27-29 Rocky Mountain Oil & Gas Assn. (annual convention), Cosmopolitan Hotel, Denver, Colo.

31 to Nov. 1 Independent Petroleum Assn. of America (annual membership meeting), Jefferson Hotel, St. Louis, Mo.

31 to Nov. 2 NLGI ANNUAL MEETING. EDGEWATER BEACH HOTEL, CHICAGO, ILL.

31 to Nov. 2 Society of Automotive Engineers (transportation meeting), Chase Hotel, St. Louis, Mo.

NOVEMBER, 1955

2-4 Society of Automotive Engineers (diesel engine meeting), Chase Hotel, St. Louis, Mo.

9-10 Society of Automotive Engineers (fuels and lubricants meeting), Bellevue-Stratford Hotel, Philadelphia, Pa.

13-18 American Society of Mechanical Engineers (75th anniversary meeting), Hilton & Blackstone Hotels, Chicago, Ill.

14-17 American Petroleum Institute (35th annual meeting), Mark Hopkins, Fairmont, St. Francis, and Palace Hotels, San Francisco, Calif.

16 American Petroleum Institute (OIIC Steering Committee meeting), San Francisco, Calif.

17 National Industrial Conference Board (general session), Bellevue-Stratford Hotel, Philadelphia, Pa.

27-30 American Institute of Chemical Engineers (annual meeting), Statler Hotel, Detroit, Mich.

DECEMBER, 1955

6-7 Petroleum Packaging Committee of Packaging Institute, Benjamin Franklin Hotel, Philadelphia, Pa.

8-9 American Petroleum Institute (OIIC meeting), Waldorf-Astoria Hotel, New York, N. Y.

11-14 American Society of Agricultural Engineers (Winter meeting), Edgewater Beach Hotel, Chicago, Ill.

JANUARY, 1956

9-13 SAE Annual Meeting, Sheraton-Cadillac Hotel and Hotel Statler, Detroit, Mich.

JUNE, 1956

3-8 SAE Summer meeting, Chalfonte-Haddon Hall, Atlantic City, N. J.

NOVEMBER, 1956

1-2 SAE National Diesel Engine Meeting, Drake Hotel, Chicago, Ill.

8-9 SAE National Fuels and Lubricants Meeting, The Mayo, Tulsa, Okla.

"HOYST WOULDN'T NEED AN ELECTRON MICROSCOPE TO SEE HIS BANK BALANCE IF HE'D READ THIS MANUAL!"

Black or Light

METASAP* ALUMINUM STEARATES
make specialty greases 6 WAYS BETTER

Whether you're making black oil greases or clear lubricants, you'll find the use of Metasap Aluminum Stearates will solve your manufacturing problems, cut costs, give you a better finished product. Check these Metasap grease bases for economical production of lubricants with any desired body:

METASAP 598—high gel type for use where high yields are of paramount importance.

METASAP 537—produces a high gel for clear, transparent greases with good lubricating stability.

METASAP GM—gives a medium heavy gel where smoothness is of prime importance.

METAVIS 540—can be used with wide range of mineral oils; produces semifluid, adhesive-type lubricant known as castor machine oil; highly economical.

1. more stable at high temperatures

2. more water-repellent

3. more resistant to centrifugal action

4. smoother in texture

5. wider in applicability

6. more economical

Samples are available for experimental work. Our research and technical staff will be glad to help you select the correct base for any given oil, or achieve any desired effect in a finished grease through use of proper soap mixtures.

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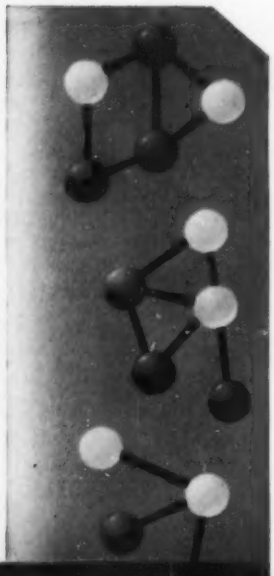
METASAP CHEMICAL COMPANY REG. U.S. PAT. OFF.

Stearates

of Calcium • Aluminum • Lead • Magnesium • Zinc



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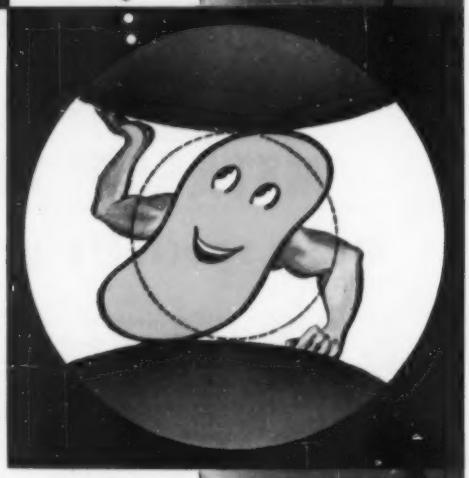
THIS $5000 BEAUTY DEPENDS ENTIRELY ON SCIENTIFICALLY CORRECT LUBRICATING GREASES

As far advanced as it is in automobile engineering, this beautiful convertible is correctly lubricated by Battenfeld products, sold and distributed under America's famous marketing names.

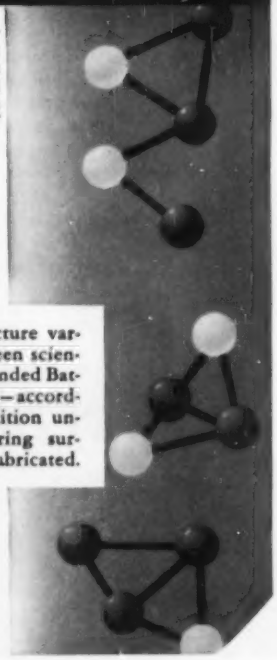
Grease is no longer just "grease". Lubricating greases are compounded products of many types, each with a prime purpose in view. Lubricating greases by Battenfeld are literally *millions of units in protective action!* . . . highly complex units whose molecular structure varies widely according to the job each type of "grease" must do.

Battenfeld is research and production headquarters for lubricating greases sold under the trade names of the nation's most famous marketers and jobbers.

Your inquiry is cordially invited.



"Never shall the surfaces meet!". . . even though pressures reach 90,000 lbs. and tolerances are as close as 1/10,000 of an inch.



Molecular structure varies widely between scientifically compounded Battenfeld greases—according to the condition under which bearing surfaces must be lubricated.

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. . . as the key ingredient in multi-purpose lubricating grease manufacture, Foote lithium hydroxide enables the economical production of a single water resistant grease that lubricates effectively at both extremely high and low temperatures.

Plan your production schedule in terms of an assured supply of Foote lithium hydroxide.

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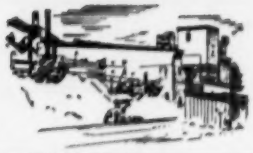

Kings Mountain, N.C. . . . where Foote is mining large deposits of spodumene.

Sunbright, Va. . . . the world's largest lithium chemical plant.

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Due to exceptionally good heating, mixing, kneading, cooling, and more rapid turnover, noticeable economy can be expected from the Stratco double stirrer kettle.

Rapid and uniform completion of the grease batch is accomplished by two counter rotative independently driven assemblies, each with multiple axial flow type impeller blades. (See illustration)

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